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THE MONUMENTAL FOUNTAIN AT THE PARIS EXPOSITION.

WE are happy to be able to place before the eyes of our readers a very important work—the monumental fountain which is to ornament the garden which is overlooked by the famous Eiffel tower.

This fountain was ordered of Mr. Francis de Saint Vidal by Mr. Dantesme, Minister of Commerce and the Industries, upon the suggestion of Mr. Alphand, director-general of the works of the exposition of 1889, and is to be placed in the center of the garden situated under the tower.

The basin in which the fountain will be placed measures about 78 feet in diameter. The fountain itself will be 39 feet in diameter at the level of the water in the basin, and 29½ feet in height above that level. It consists of eleven figures of one and a half times the size of life. Six of these figures form the central group, and five are placed around and beneath in a circumference of 28 feet diameter. These last named figures represent the five divisions of the world, but much more by their character and action than by their attributes.

Europe, represented by the figure of a woman aged forty years, leaning upon those great agents of thought the printing press and the book, seems as if buried in deep and thoughtful meditation.

In America, it is an entirely different order of ideas; it is youth, energy, virginity—the reveille of civilization, a somewhat violent one, and all full of the boldness that characterizes the Americans.

Asia, the cradle of the human race, well represents voluptuousness and sensuality. The pose, the body bent upon itself, the expression of the face, all at once express the energy and the *abandon* of passion among Oriental peoples.

Africa, represented by the figure of a woman in a timorous attitude, is indeed the symbol of savage peo-

THE MONUMENTAL FOUNTAIN—FRENCH EXPOSITION OF 1889.

ples enslaved by civilization until the day when they shall be able to associate themselves therewith.

In Australia, the savage state remains intact. The figure, that of a woman, well renders the as yet untamed animal confiding in her primitive strength and ready to fall upon her prey without waiting to be attacked.

In the central composition, six figures are grouped around a sphere borne by clouds. At the upper part of the group, the genius of Light, with wings outspread, and a torch in the right hand, is taking flight, and unveiling Humanity. The latter is represented by the figure of a woman seated upon the sphere.

Above Australia, Mercury is descending from the clouds, holding a caduceus in one hand and a bag of money in the other, these two being the emblems of eloquence and persuasion.

Above Asia and Africa are Love and Sleep in the shadow of flowing drapery, as if in a cradle. Finally, between Europe and America, there is a young girl, symbolical of History. On the shield that she holds in the left hand are inscribed the two dates 1789–1889.

The water will flow in a thin sheet from the drapery that connects the figures of the central group, and will escape in a shower and very fine spray from the clouds provided to this effect, and from the center of which the sphere and the six central figures will seem as if suspended.—*Le Monde Illustre.*

THE PARIS EXHIBITION.

In June, 1883, a few French members of Parliament, among whom were MM. Herve-Mangon, Liouville, and Million, urged M. Herisson, minister of commerce, to consider the desirability of holding a national exhibition in Paris in 1885. Public discussions in the press and elsewhere followed, with the result that it was considered best to hold a "universal" exhibition in Paris in 1889, the centenary of the French revolution in 1789. M. Jules Ferry, who was then president of the council, considered that such an exhibition would be not alone good in itself, but tend to keep peace in Europe. On November 8, 1884, M. Jules Grevy, president of the republic, signed, upon the recommendation of M. Rouvier, minister of commerce, a decree that a universal exhibition should be opened in Paris on May 5, 1889, and should be closed on the 31st of October, in the same year. A deliberative commission was at the same time appointed to consider the best method of carrying out the project, and it recommended that other nations should be invited to take part in the exhibition, on the economical ground that it celebrated the French centennial of industrial freedom. Later on, under the Freycinet ministry, M. Lockroy, minister of commerce and industry, asked credits from the chambers for the purpose. The government resolved to leave the matter to private initiation, and that the whole cost of the enterprise should not fall upon the state, as in 1878. It pronounced, therefore, in favor of a system of organization by the state in alliance with a guarantee society, as in 1867, which had been found to work well. This society guaranteed the state eighteen million francs receipts, and gave certain guarantees in the event of the expenses exceeding the amount calculated. The society acted by means of a board of control and finances, composed of eight municipal councilors, seventeen senators, deputies, and agents of the state, and eighteen subscribers to the guarantee fund, each commissioner representing one million francs. This commission enjoys, with the state and municipal council, the right of being consulted by the minister of commerce on all questions relating to the financial aspects of the exhibition. In short, the state has control of the exhibition, the city of Paris has a voice in the control, and the guarantee society does not lose sight of its capital. The state will be reimbursed to a large extent by the great circulation of money and extra surplus from its indirect imports. The city of Paris will be largely reimbursed by increased receipts in octroi duties, and the guarantee society is safeguarded by the receipts of the exhibition. A law, dated July 6, 1886, sanctioned this combination, and a few days afterward, on the 28th of July, a decree regulated the organization of the services. M. Edward Lockroy, minister of commerce and industry, received the title of commissioner-general of the exhibition; M. Alphand, that of director-general of the works; M. Georges Berger, that of director-general of the exposition; and M. Griton, director-general of the finances. M. Bartet was appointed engineer-in-chief, MM. Contamin, J. Charton, and Perron have control of the metallic constructions, MM. Bouvard, Dutert, and Formige are the architects of the exhibition, and MM. Laforcade and Lion have charge of the gardens and plantations. A ministerial order, dated August 26, 1886, appointed a consultative committee of three hundred persons, under the title of the grand council of the universal exhibition of 1889, and this was subdivided into twenty-two consulting committees to watch over various departments of the works. Foreign committees, established at the request of the French government, were each invited to be represented by a delegate charged to deal with questions interesting to the nation he represented. The minister and the commissioner-general do not correspond directly with foreign exhibitors.

The ground plan of the whole exhibition, published herewith, will make clear the general arrangement. The portions devoted to exhibits from Great Britain are represented by the darkest areas. The exhibition is divided into three great parts. One part, bounded on the north by the Trocadero, is on the north bank of the Seine, and devoted chiefly to exhibits relating to horticulture and arboriculture. It is connected with the chief part of the exhibition in the Champ de Mars by the Pont de Jena, and the main thoroughfare passes under the center of the Eiffel tower—the positions of the four feet of which are represented in the map.

In that part of the exhibition which covers the Esplanade des Invalides are many scattered buildings. One of them is for miscellaneous exhibits, and some of the others for exhibits by the French naval and military authorities. Others are for exhibits from the French colonies. Places are being built in the Seine for floating exhibits of boats and ships. Some English steam-launches are expected to be there.

At one time the plan was under consideration of connecting the Champ de Mars and the Esplanade des Invalides with a railway denoted by the dotted line, R R. Unfortunately for the public, this idea has been abandoned, and they will have to go an immense way round by the route marked W Y. This length, however, will be traversed by a railway, which will carry passengers for a small fee.

Plan II. represents part of the palace of the Champ de Mars, which plan we copy from the *Bulletin Officiel* of the exhibition. The shaded upper part represents a portion of the great machine gallery. The galleries numbered 41 will be devoted to exhibits connected with the working of mines; 47, to leather and skins; 45, chemical products; 43, hunting and fishing appliances; 42, forestry appliances; 44, agricultural products, not alimentary; 46, bleaching and coloring; 31, linen; 39, encampment appliances; 38, arms, portable; 35, hosiery and dress accessories; 33, silks; 34, lace and lace making; 36, dresses for the two sexes; 40, toys; 37, jewelry. Returning to the upper portion of plan II., gallery 27 is devoted to heating appliances; 25, bronzes and artistic castings; 26, clocks and other time-keeping instruments; 29, ornamental leather work; 28, perfumery; 22, wall papers; 18, decoration and upholstery; 21, upholstery and tapestry; 17, these three galleries are devoted to furniture; 20, two galleries will contain specimens of ceramic art; 19, crystal and glass work; 24, goldsmiths' work; 23, cutlery; 20, mosaics. The pavilions of various Oriental nations will border this hall of miscellaneous exhibits, on that side of it nearest the Avenue de Suffren. The central portion of the lower part of the plan represents the area allotted to groups III., IV., and V., and to class 60, group VI.

By a ministerial order of August 2, 1887, an international congress of photographers will be held in Paris in connection with the exhibition; and by a resolution dated July 16, 1888, of the minister of commerce and industry, director-general of the exhibition, a committee of organization was nominated to make the necessary arrangements. That committee includes the names of some men of great celebrity, including that of M. Edmond Becquerel, the chief pioneer and discoverer in relation to photography in natural colors. No great progress has been made in this research since his experiments of half a generation back. To this day such pictures cannot be fixed, and are slowly destroyed by light. MM. Paul and Prosper Henry, of Paris, who have done such good work in stellar photography, are among the members of the committee, and its president is Dr. Janssen, director of the Astronomical Observatory at Meudon, who discovered in India how to photograph the red flames of the sun without an eclipse. M. Davanne, vice-president of the French Photographic Society, is one of the most active members of the committee. The congress is expected to be held at some period between July 15 and August 15, 1889. We are indebted to the *Engineer* for the foregoing and for the plans herewith given.

MANCHESTER SHIP CANAL—PLANT AND MACHINERY.

By L. B. Wells, M. Inst. C. E.*

At the meeting of the Association in Manchester last year, Mr. Leader Williams, the engineer, read a description of the Manchester Ship Canal, which is being made to give access to vessels of great burden into docks to be constructed by the canal company at Manchester, Warrington, and elsewhere. The width of the canal is 120 ft. for a depth of 26 ft., the slopes varying according to the nature of the material cut through. To complete the canal, locks, and docks, about 50 millions cubic yards of excavation of different descriptions of material, varying from sandstone rock to river sludge, has to be moved and deposited, and as the canal and works connected therewith have to be completed in four years from the date of the contract, it is evident that an unusual effort must be made to keep pace with the exigencies of the situation. Mr. T. A. Walker, who has taken the contract for the whole work, has entered upon it in a spirit that bodes well for the accomplishment of his undertaking. In all that is done from Eastham at the mouth to the terminus at Manchester, there appears to be abundance without waste of men, machines, and material of every description. From the staff downward the same principle is manifest. The engineer has divided the length, 35½ miles, into sections, and so for the purposes of his work has Mr. Walker. He has nine sections. Each section is assigned to an agent, with a separate staff of sub-agents and engineers looking to the agent for instructions. In their charge is also placed the plant allotted to each section. They have their own workshops, machinery for repairing plant, timekeepers, etc. The whole is controlled by an agent-in-chief, with headquarter staff, from the chief office in Manchester, Mr. Walker devoting as much time and attention as his other important engagements will permit. Each section is worked as a separate contract, and thus the responsibility and individual interest of the agent is secured, and a healthy spirit of rivalry promoted, which tends to rapidity of work and development of energy throughout the contract, and at the same time the ship canal company have secured one head, whom they hold responsible for the due fulfillment of all engagements entered into, which simplifies their position and renders it far safer than if several different contracts were pending, a delay in one of which would prejudice the whole undertaking.

The docks, locks, river walls, etc., are each and all big of their kind, and give ample scope for professional ability to display itself; but as the canal is practically a cutting from end to end, the great feature from a contractor's point of view is the earthwork. Already between five and six million cubic yards have been shifted, and the work is practically going on along the whole length, and to prosecute this the contractor has provided 5,000 wheelbarrows, 3,000 wagons, 87 locomotives, and 65 machines for excavating by steam power, and many more are still on order. The wheelbarrow is used when stripping soil and for removing a few feet below the surface when the place of deposit is near at hand. Where a high embankment is formed near a deep cutting, the old-fashioned horse road is in use, a man in the shafts guiding the barrow up a steep incline, a horse pulling it up to the platform on top. Alongside a framing beveled to the incline, with upper surface sufficient to accommodate six wheelbarrows, is pulled on rails to the summit by a small stationary engine, while close at hand a steam crane, with a jib 75 ft. long, is employed lifting small iron trucks, which are run on rails from the cutting within its radius, and when lifted to the top are similarly run off to the tip. In places the ordinary earth wagons are filled by hand, but machinery is employed to a very large extent indeed.

Messrs. Dunbar & Ruston's Steam Navvy.—The great bulk of excavation is being done by the steam navvy, of which forty-five of Messrs. Dunbar & Ruston's are already supplied, and ten more are on order. These machines have been in use for several years, and their efficiency is established. The framework generally, including the platform, pillar, and jib, are of wrought iron; the boiler is of the vertical type, with a cross tube, the 10 horse power engine being attached to it and working vertically. The buckets are of wrought iron, with steel prongs or teeth projecting beyond the cutting edge. Different sizes of buckets are used in the various descriptions of material found. The largest holds 2¼ cubic yards, and two buckets full load a wagon; the smallest, 1¼ cubic yards, and three of these load a wagon. The teeth are attached by bolts, and are readily changed, different shapes and strengths being used for different descriptions of material. The bucket, with a hinged back, is attached to an arm suspended from the jib, which arm can be lengthened or shortened to suit the work to be performed. The bucket is raised and forced through the face of the cutting by means of a chain carried from the drum over the top of the pillar round the end of the jib. The machine is controlled by two men, a driver and a wheelman. The driver raises the bucket while making its cut, swings the jib so that the bucket rests above the wagon into which it is to be emptied, returns the bucket, and lowers it to the face of the cutting. The wheelman regulates the depth of the cut, retires the bucket from the face of the excavation when it is filled, and opens the back for discharging the load. The navvy is moved forward or backward by its own machinery, and, when in position, the weight is taken off the wheels by jack screws and blocks, giving it a firm base to work upon. The weight is about 32 tons, and the machine works on rails 10 ft. 6 in. apart, but for ordinary locomotion wheels are provided at the 4 ft. 8½ in. gauge. The output varies according to the character of the material, the depth and width of cutting, and the arrangements made for moving the wagons. With the large buckets, in soft sand or loam, 340 to 350 wagons are loaded in a day of ten hours, and as many as 518 wagons have been loaded in twelve hours; the number of men and horses attending on the machine varies with the character of the material and the output. In very hard marl, which is prepared for excavating by blasting, the output is about 120 wagons a day.

Whittaker Steam Crane and Navvy.—The Whittaker steam navvy is also coming largely into use; the machine is constructed to act as a steam traveling crane, propelling itself on the ordinary 4 ft. 8½ in. railway, with outer wheels 7 ft. 6 in. gauge, on which it rests when in position, and requires no blocking. The crane is provided with a bucket attached to a quadrant, and this quadrant is connected to the jib by bolts, and is fixed higher and lower as required; the cutting is done by the chain over the end of the jib, as in Messrs. Dunbar & Ruston's machine.

A steam cylinder 7 in. in diameter is hung in trunnions on the jib, and works a crank 18 in. long keyed on to a shaft. A second crank 9 in. long is keyed at right angles on the same shaft, and to this the quadrant carrying the bucket is attached. By working the cylinder the bucket can be advanced against the face or withdrawn from it, and the power is so balanced by means of the double crank that if a bowlder or other obstruction puts a pressure of over five tons on the bucket, it retires automatically, and having passed round the obstruction, completes the cut above it. The standard machine is attached to a ten-ton crane, which weighs in all 32 tons; but the bucket and apparatus can be applied to Priestman's, Smith's, Wilson's, and other cranes of various sizes and powers. By removing two cotters the bucket and quadrant are detached, and the crane ready for lifting in the ordinary way. Eleven of these have been delivered.

The steam navvies are worked from the bottom of the excavation, and a gullet or channel has to be provided for them by excavating with wagons or by some other means. The best results are obtained in a cutting from 18 ft. to 22 ft. in depth, when the machine advances at about the rate of 30 ft. per diem, being moved forward about 3 ft. each time. If the cutting is sufficiently wide, and the drainage will permit a wagon road to be laid on each side of the navvies, the best results can be obtained. Each cut occupies something less than a minute, and the difficulty is to keep the machine well supplied with empty wagons. Water has to be kept under by pumping, so that the men and horses employed in moving the wagons and working about the machine, clearing and laying roads, etc., can continue at their work.

German Excavators.—As a contrast to the steam navvies, we have the German and French excavators; three of the former are already in use. These machines work on the top of the slope on lines of rails along which they move continuously while at work. In the German excavator the framing is of wrought iron. It travels on three lines of rails laid on timber sleepers 20 ft. long. The rails are of heavy section, single flanged, the outer rails being 15 ft. apart; the intermediate rail is laid 3 ft. from the front.

On these travel sixteen wheels, four on each front rail and eight on the back one, provided with springs. From the front of the machine two horns project, hinged at the foot, and between these the frame or jib, along which the buckets or scoops travel, is hung. The jib is pivoted from the top tumbler immediately over the hopper, and is raised or lowered by a chain carried over the horns. The buckets or scoops are segments of a circle unprovided with backs, and gradually fill as they are pulled up the face of the excavation, and discharge into the hopper when passing over the top tumbler. The length of the jib is between 50 ft. and 60 ft.; the attachment to the scoop is made by a bracket 14 in. long, and there are three intermediate links of equal length between each scoop; on the top shaft are fixed two light saddles, on which the buckets turn. The boiler is single-flued and multitubular, 5 ft. diameter, 16 ft. long, and blows off at a pressure of 112 lb.; it is fixed above the inner wheels, and helps to counterbalance the machine. The machinery is driven by a pair of non-con-

* A paper read before the British Association, Section G, Bath, 1888.

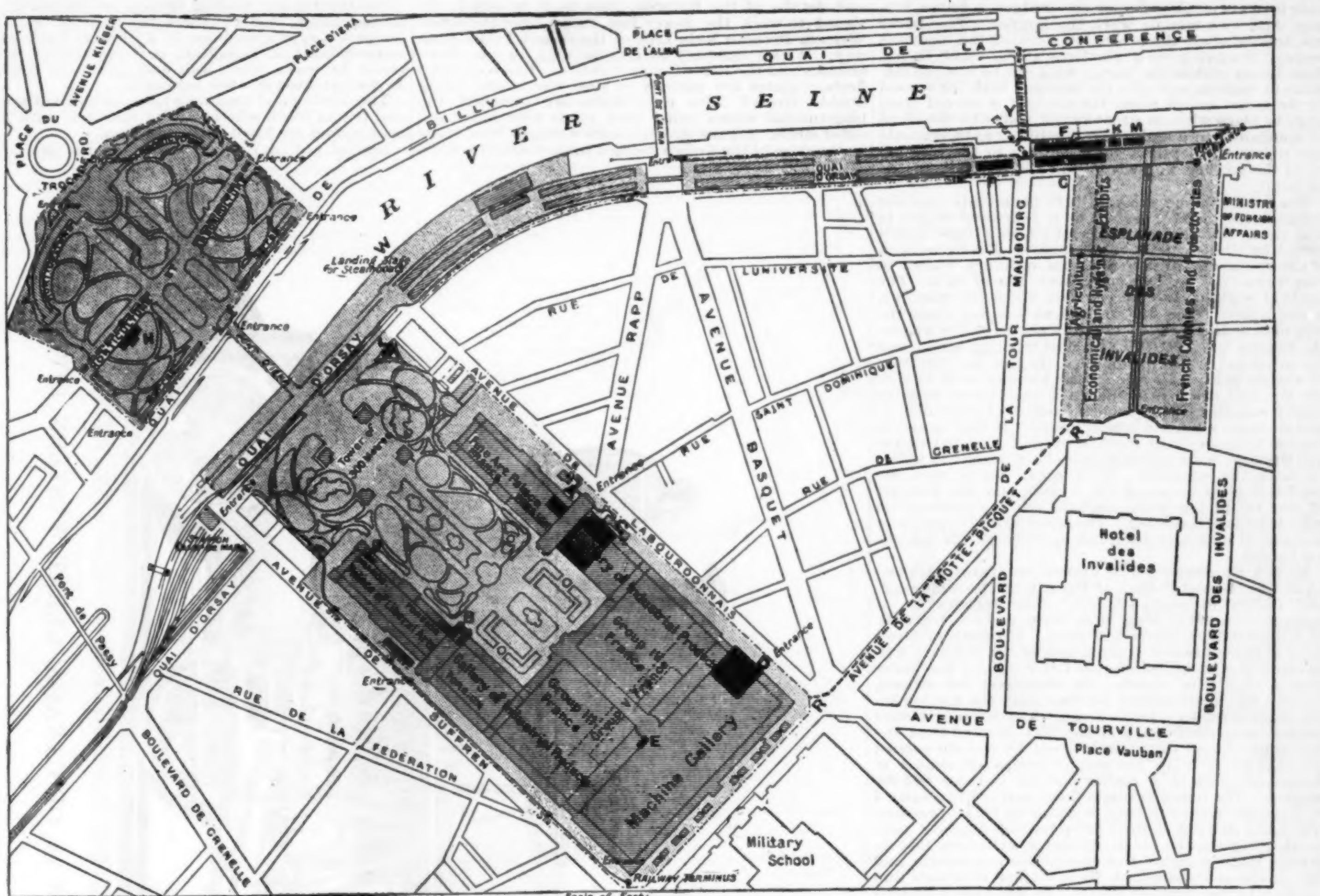


Fig. 1—PLAN OF THE PARIS EXHIBITION.

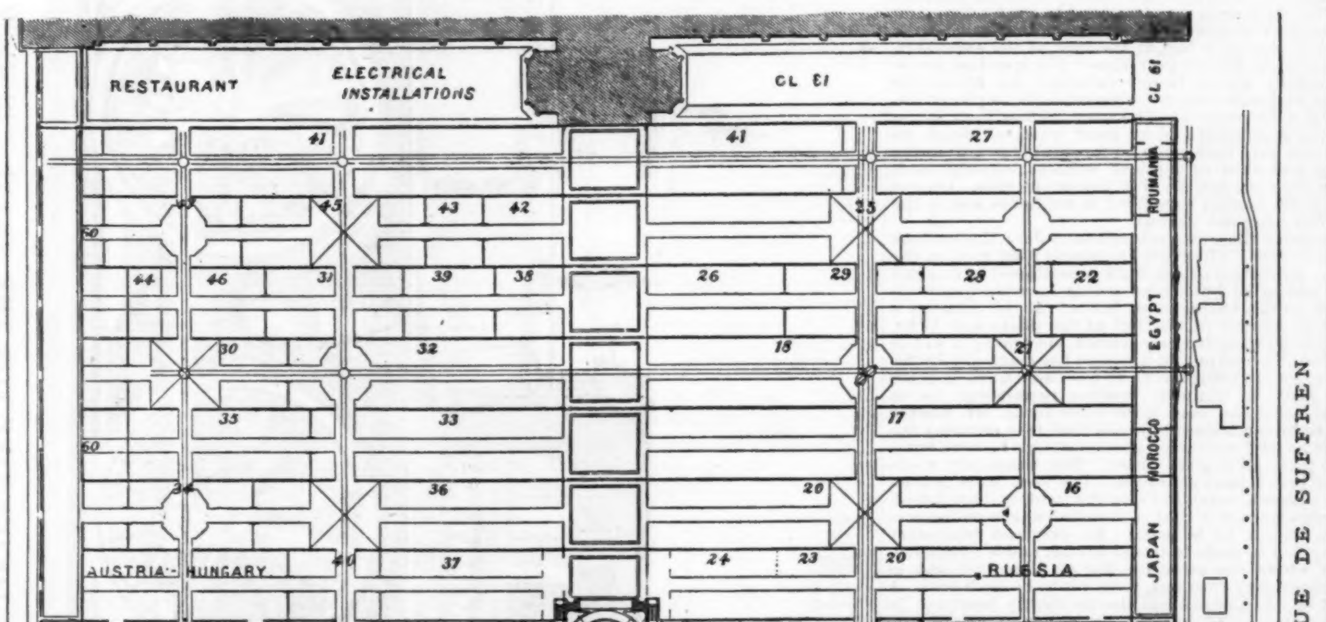


Fig 2—PLAN OF THE CHAMP DE MARS PALACE.

THE PARIS EXHIBITION, 1889.

densing 9 in. cylinders, 13 in. stroke, and is provided with countershafts, geared wheels, and friction clutches, for obtaining the necessary power and speed as required and throwing the different parts in and out of gear. Four men are employed upon the dredger: a driver, fireman, and two men to work the hopper. The driver has control of all the levers for working the machine proper. Standing on a platform at the front, he has three levers within his reach; with one he sets the machine in motion, and also the scoops; with the second he stops the scoops when the dredger is moved from place to place without excavating; and with the third he constantly lifts and lowers the jib, so as to regulate to a nicety the depth of cut according to the inequality of the surface worked on and the hardness of the material.

The dredger moves at about 12 ft. per minute; and the scoops travel at the speed to fill a four yard wagon in that time. There is no means of altering these speeds except by altering those of the engine. The framework of the dredger is built to allow an ordinary wagon to pass under the hopper on its own line of rails. The mode of working is to place a train under the machine, which is then set in motion, and as it moves along the wagons are filled; when over the center of the wagon, the hopper is reversed by two men working levers, and the other end of the wagon filled. In this way the train of wagons is loaded ready for the locomotive to haul to the tip, and if space permitted a continuous train of empty wagons to be stationed, there need be no delays, and a wagon a minute is easily filled. It is proposed to reverse the hopper by machinery, and then the driver and fireman, with perhaps one other man, will suffice to work the machine. Four other shovel men are needed to clear up about the wheels, and the number of the rail-laying gang depends on the material on which the road is carried. The weight of the excavator is about 60 tons, and for a fair day's work 420 wagons are loaded.

French Excavator.—The French excavator, supplied by Messrs. Boulet et Cie., of Paris, is of the same type, but differs in many details. The framing is of wrought iron, 30 ft. long, 10 ft. wide, and the top tumbler shaft is 18 ft. above rail level. It travels on three lines of rails of heavy section, laid on the ordinary 9 ft. sleepers, the front rails being 1 ft. 8 in. and the inner ones 4 ft. 8½ in. apart. On these rest ten wheels, four of which are geared for traveling, the motion being transferred by a pitch chain. The horns or ladder project from the front, and the jib is pivoted from the top tumbler, and raised or lowered by a chain carried over the horns. The buckets or scoops are similar in form, and work in a similar manner to those last described. The boiler is single-flued and multitubular, 4 ft. diameter and 21 ft. long, working at 140 lb. pressure. The main driving engines are a pair of diagonal noncondensing engines 9½ in. diameter cylinders, 19½ in. stroke, making eighty-five revolutions per minute, and the power is transmitted by a system of wheels and pinions to the tumbler shafts. In addition a smaller pair of engines, 6 in. cylinders, 6¼ in. stroke, impart a traveling motion to the excavator, and also lift and lower the jib. Five men are employed on the machine—a driver, fireman, a man to attend to the buckets, and two men to regulate the shoots. A line of rail for the passage of wagons is laid at the back of the excavator, and the shoots deliver over these; the speed at which the machine moves is not sufficient for filling the wagons, and each wagon has therefore to be placed under it by a locomotive. The machine has been in use for three months and done good work, although its operations have been crippled for want of length in the cutting and want of depth of suitable material, rock having been reached at 15 ft. below the rails. On one occasion 572 wagons were filled in ten hours, and in the night following 504 wagons.

A second of these excavators is on order; the machine weighs 58 tons. There are at present 8,500 men on the works. At certain places work is continued by day and night, and at all important points an extra quarter is worked in the twenty-four hours. At the cuttings a patent oil lamp is in use, but at the docks and locks, when the building is fairly started, electric light will be provided. The output in a month has reached 1,300,000 cubic yards, and this has to be increased until 2,000,000 cubic yards is attained, weather permitting, for at present a wet day loses 50,000 cubic yards. Mr. Walker seems to have convinced himself that true economy can be best insured by having good materials to work with, and to keep all in good order. The temporary roads are the best I have ever seen. The steel rails, laid on sound sleepers, weigh 56 lb. to the yard, and are fished. The consequence is that a derailed wagon or locomotive is seldom to be seen. An overland temporary railway will be made from end to end, and is completed, except where the estuaries, Barton aqueduct, and in some cases river crossings, have yet to be dealt with. A line of telephone wires will also be shortly provided. In addition to the 100 locomotives, either at work or on order, there are forty portable engines, upward of fifty steam pumps, and an equal number of steam cranes. Among the pumps are two 31 in. diameter bucket pumps, capable of lifting 200,000 gallons per hour each; these were employed on the Severn tunnel. The other items of the contractor's plant are provided in due proportion.

No notice of the Ship Canal works would be complete which omitted to mention the care shown by the contractor for the welfare of his workmen. On each section huts or rooms are provided to which men suffering from accidents are taken. Two permanent hospitals have been built, containing twenty to thirty beds, and more are to follow. In these hospitals not merely cases of accident, but also of acute rheumatism, are treated, and while in hospital a proportion of wages is given the sufferer, half pay to married men with families, and one-fourth pay to single men. A deduction from the wages of 1d. a day is made to help to defray the expense, Mr. Walker finding the balance. Mission rooms have also been established. Four of these, accommodating from 400 to 700 persons, are already in use, and one is to be provided for each section. The cost of these and of a missioner for each is borne by Mr. Walker.

A GAS meter that it is believed precludes fraud has a receptacle into which, when a certain number of pennies are dropped, a certain amount of gas is liberated. When this is exhausted, drop in more pennies. They accumulate in a locked box, and are collected at intervals.

EXPRESS LOCOMOTIVE, GRAND TRUNK RAILWAY.

WE give illustrations containing a perspective view and details of the Empress class, as it is called, designed to work the heavy fast trains over the Great Western Division Main Line of the Grand Trunk Railway. We are indebted to *Engineering* for our illustrations and the following particulars. The boiler and firebox plates are entirely of steel, the seams being double riveted. The rivet holes are punched, the longitudinal seams being butt joints with inner and outer strips. All the stay bolts are wrought iron, those in the sides of the firebox being 1 in. in diameter, while those of the roof are 1⅛ in. in diameter, and are arranged in the manner adopted on the Caledonian Railway by Mr. Drummond, the joint with the steel crown plate being made by a coned head on the stay bolt and drawn up to its countersunk seat on the plate by a nut on the inside.

The tubes are wrought iron 1¾ in. external diameter and are fitted with copper ferrules outside at both ends, the holes in smokebox tube plate being bored 1⅞ in. in diameter, and in firebox tube plate 1¾ in. in diameter; the tubes are swaged down at this end to suit, thus allowing them to be easily withdrawn.

The main frames are of a composite type, the rear portions being of 1 in. steel plate, this style of frame being used for these parts for the reason that it enables a much larger grate area to be obtained than could have been got with bar frames of the usual American type. The front parts of the frames are of wrought iron and are of the bar type; they are connected to the main plates by large palms with grooves and checks accurately fitted.

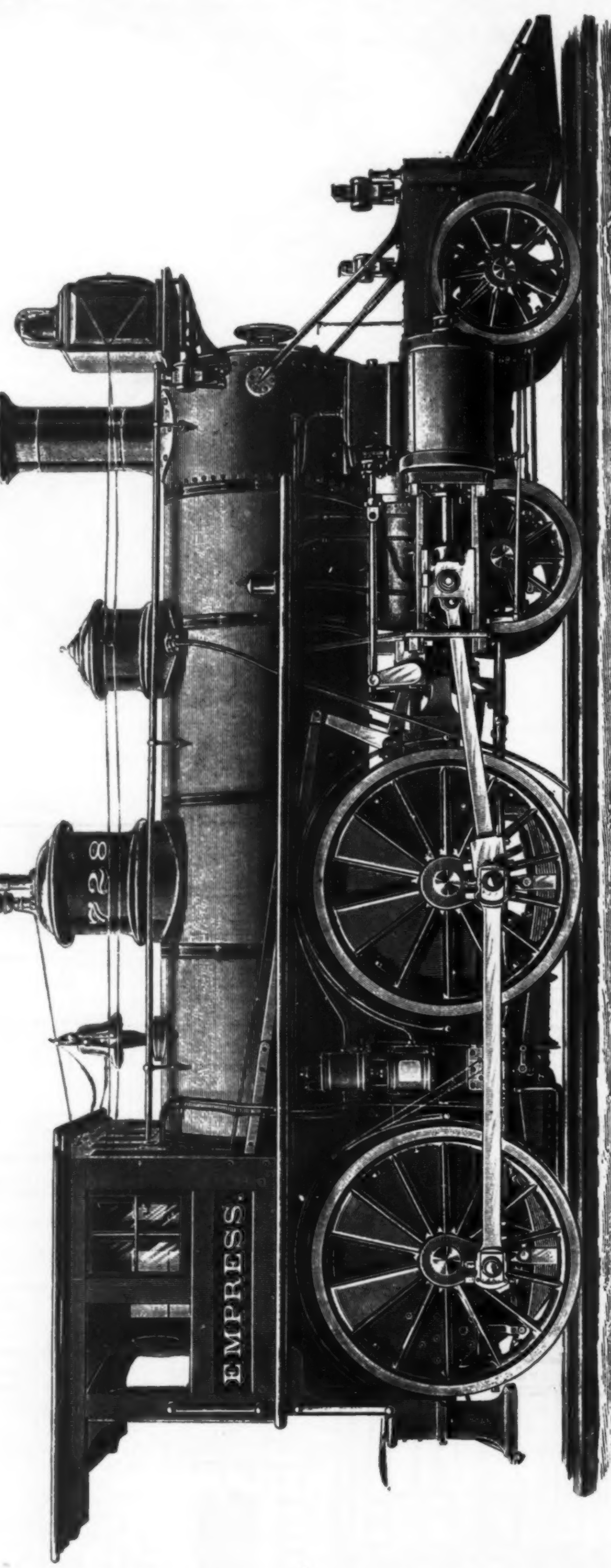
The driving and trailing springs are underhung and are equalized, the equalizer being fitted with hook hangers, a type introduced in a class of tank engines recently built at Hamilton, as it economizes room, is cheap to make, wears well, and allows the springs to be disconnected in a few moments.

The driving and trailing wheels, as well as the engine and tender truck wheels, are of cast iron, with hollow spokes, and are fitted with steel tires.

In the ordinary American engine the practice has been to put small truck wheels under the front end this feature, together with the excessive weight generally thrown on this end of the engine, has a tendency to cause the truck journals to heat. These two points are, in the locomotive under notice, kept well in view, and truck wheels of 3 ft. 6 in. in diameter are used, the weight being kept down.

The cylinders are fitted with pistons having plain cast iron rings sprung in, and are provided with tail rods. The slide valves, crossheads, steam and exhaust pipes are of cast iron. A section of one of the cylinders is given in Fig. 5, while Fig. 4 shows the saddle casting to which the cylinders are bolted, and which in American locomotives so well secures "squareness" at the leading end of the engine. Detail views of the crossheads and connecting and coupling rods are given in Figs. 8 to 16.

The smokebox (see Fig. 3) is fitted with a deflecting



EXPRESS LOCOMOTIVE FOR THE GRAND TRUNK RAILWAY OF CANADA, GREAT WESTERN DIVISION.

plate and netting to prevent spark-throwing. The door and front are of cast iron, as in the smoke stack base, which is fitted with a steel barrel lagged with Russian iron, and mounted with a polished cast brass top. A detail of the exhaust nozzle is given in Fig. 6.

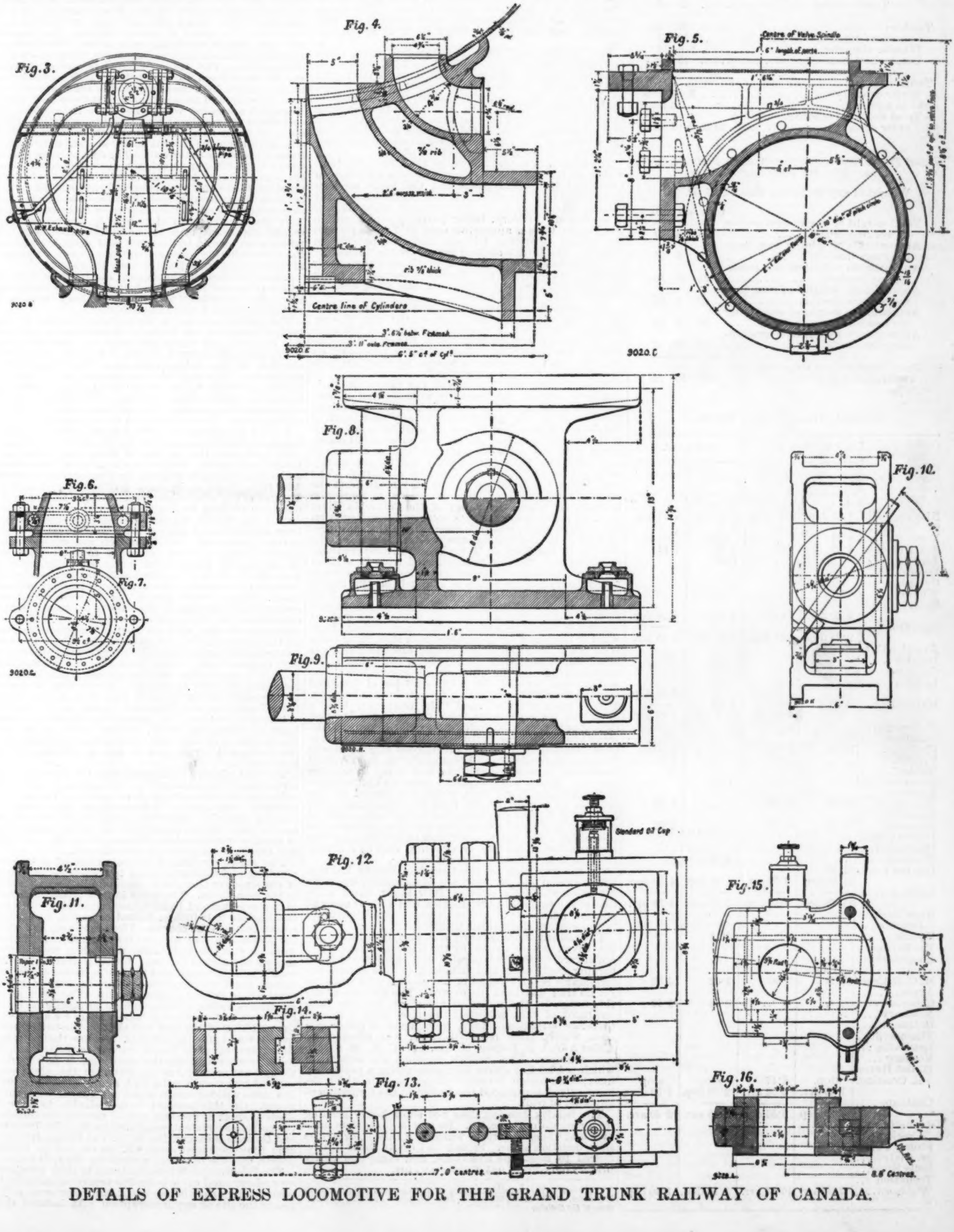
The engines of this class are fitted with screw reversing gear, two glass water gauges, Siebert's sight-feed lubricator for cylinders and valves, two Gresham injectors, and a four-pocketed chime whistle. The safety valves are 3 in. in diameter and blow at 160 lb. per square inch; the safety valve spring is in compression.

The engines have been constructed at the works of the company at Hamilton, from the designs of Mr. C. K. Domville, the mechanical superintendent of the Great Western division of the Grand Trunk, to whom we are indebted for the drawings from which our engravings have been prepared. We append a tabular statement of the chief dimensions of the engines, and also particulars of the express trains worked by them.

Leading Dimensions and Particulars.

	ft.	in.
Cylinders:		
Diameter	0	19
Stroke	0	24
Length of ports	1	6
Width of steam ports	0	1½
" exhaust	0	3⅜
Centers of cylinders	6	5
Valves:		
Lap	0	0 15/16
Lead	0	0⅛
Travel in full gear	0	5 1/16
Frames (plate—steel):		
Distance apart	4	1
Thickness	0	1
Frames (extension—iron):		
Distance apart	3	6⅛
Thickness	0	2¼
Depth	0	5

	ft.	in.
Boiler:		
Diameter outside (smallest ring)	4	7¼
Thickness of plates (steel)	0	0 7/16
" tube plate (smokebox)	0	0⅝
Firebox (outside—steel):		
Length	6	10
Width	4	0
Depth from center line of boiler	5	6
Firebox (inside—steel):		
Length at bottom	6	2¼
" top	5	11¼
Width at bottom	3	4⅜
Thickness of crown, sides, and end	0	0⅜
" tube plate	0	0⅝
Depth inside	6	5
Diameter of stay bolts	0	1
" roof stay bolts	0	0⅛



DETAILS OF EXPRESS LOCOMOTIVE FOR THE GRAND TRUNK RAILWAY OF CANADA.

	ft.	in.
Wheels:		
Driving and trailing diameter	6	0
" truck, diameter	3	6
Centers of driving and trailing wheels	8	8
" truck wheels	6	10
Total wheel base	23	1

Heating Surface, etc.:	sq. ft.
Firebox	128·50
Tubes	1281·24
Total	1409·74
Grate area	20·81
Flue area	3·50

Weight of Engine, Working Order:	tons.	cwt.
On truck	15	9
" driving wheels	13	14
" trailing "	13	10
Total weight	42	13

Tender:	ft.	in.
Centers of trucks	10	0
Wheels, diameter	3	6
Total wheel base	15	0

Tank:	
Water capacity	3,216 gals.
Coal capacity	6 tons.
Total weight of tender in working order	35 tons 15 cwt.

Grand Trunk Railway. Great Western Division. Main Line. Niagara Falls and Windsor.

Weight of express trains, Nos. 53, 55, 52, 54.

	tons.	cwt.	lb.
Total weight of engine and tender in working order	78	8	0
Approximate weight of two baggage cars (loaded)	53	8	84
Approximate weight of one smoking car (loaded)	21	12	16
Approximate weight of two passenger cars (loaded)	48	3	94
Approximate weight of one dining car (loaded)	36	4	12
Approximate weight of four sleeping cars (loaded)	131	19	32
Total approximate weight of train with engine and tender	369	16	14

Schedule Time of Above Trains.

	West Bound.		East Bound.	
	No. 53.	No. 55.	No. 52.	No. 54.
	a. m.	p. m.	a. m.	p. m.
Niagara Falls	8·05 dep.	2·45 dep.	8 20 arr.	7·55 arr.
St. Davids	8·15	..	8·15	..
Merritton	8·25	3	stop	stop
St. Catharines	8·29	3·05	7·56	7 34
Jordan	..	..	7·45	
Beamsville				
Grimsby				
Winona				
Stoney Creek				
Hamilton	9·20 arr. 9·25 dep.	4 arr. 4·10 dep.	7 dep. 6·55 arr.	6·40 dep. 6·35 arr.
Junction Cut.				
Dundas				
Copetown				
Lynden	..	4·43		
Harrisburg	10·05	4·50 arr. 4·55 dep.	6·23	6·07 dep. 6·03 arr.
St. George				
Dumfries				
Paris	10·21	5·20	..	5·50
Princeton	..	5·37	..	5·37
Gobles				
Governors rd.		..	5·46	
Eastwood				
Woodstock	10·52	5·59	..	5.20
Beachville				
Ingersoll	11 05	6·15	..	5·02
Patton's Sidg				
Dorchester				
Waubuno		..	4·57	
London East	11·35			
London	11·40 arr. 11·45 dep.	6·50 arr. 7·10 dep.	4·45 dep. 4·30 arr.	4·30 dep. 4·25 arr.
Hyde Park Junction				
Komoka	..	..	4·13	
Mt. Brydges				
Longwood				
M. C. R. Cross	p. m. 12·21	7·46	3·52	3·50
Appin				
Glencoe	..	..	3·43	3·40
Newbury				
Bothwell				
Thamesville				
Lewisville				
Vosburg				
E. and Huron R. Crossing.	stop.	8·47	stop	stop
Chatham	1·20 arr. 1·30 dep.	8·50 arr. 8·55 dep.	2·50 dep. 2·45 arr.	2·50 dep. 2·40 arr.
Jennette's Creek				
Stoney Point.				
St. Clair				
Belle River				
Tecumseh				
Windsor	2·30 arr.	10·05 arr.	1·40 dep.	1·40 dep.

[Continued from SUPPLEMENT, No. 684, page 10922.]

THE CANADIAN PACIFIC RAILWAY.*

By Thomas C. Keefer, President Am. Soc. C. E.

The Mountain Section.—In Canada the Rocky Mountains maintain a nearly northwest direction, and may be said to terminate as a distinct range between the 51st and 52d parallel; thence descending to the Peace River Pass, latitude 56 north, which is only about 2,000 feet above sea level. All the rivers on the eastern slope of the Rockies penetrate the range to a greater extent the further north they are found, and the Peace River is the first which cuts entirely through the Rocky Mountain range and heads behind it, draining the table land between the Coast Range and the Rockies. Between Peace River and the international boundary, some ten passes have been explored, all lowering northward and diminishing from 7,000 to 2,000 feet; the central one, the Yellow Head Pass, with an altitude of 3,733 feet, having been selected by the government in the first instance as the route for the railway. The range, which has an average breadth of 60 miles at the 49th parallel, decreases at the Peace River to 40 miles or less.

The "timber line," which in Colorado is about 11,000 feet above sea level, is reduced to 7,000 feet in the Canadian Rockies; and in the latter, above the height of 6,000 feet, snow falls to some extent in every month of the year. Above this elevation, large patches of perennial snow are met with, and it is in the Canadian extension of the Rockies that true glaciers make their first appearance. These, fed by large snow fields, are the sources of the numerous streams which give summer supply to the great rivers of the plains.

The mountain ranges known as the Cordillera Belt, which, on the 40th parallel, spread over a longitude of 1,000 miles in Utah, Nevada, and California, are here compressed into less than half that width—one of the ranges, an extension of the Olympic Mountains of Washington Territory, being partially submerged in the Pacific Ocean, appearing only in Vancouver and the Queen Charlotte Islands, and reappearing in Alaska. The three mainland ranges are the "Rockies" or Continental Divide (which in Canada shed their waters into the Arctic and Hudson's Bay on the north and east and into the Pacific on the west) and the "Gold" and "Coast" ranges.

The mountain section extends from the eastern slope of the Rockies to the terminus at the city of Vancouver in the Strait of Georgia, a distance of 522 miles by the railway, but less than 400 as the crow flies—the railway for nearly the whole distance threading its way through the permanent troughs of what has been described as a "sea of mountains."

While driving the line across the plains on their southern location, the company were seeking a more southern crossing of the mountains, and had obtained the consent of the government to any pass south of Yellow Head, provided it was at least 100 miles north of the international boundary. The government standard of road was one with maximum grades of one per cent., and the Yellow Head Pass lost its superiority when grades of 116 feet per mile were permitted. The Bow River Valley led up by an easy route from the 50th parallel to more than one pass through the Rockies, by which the valley of the Columbia River could be reached, always with more or less difficulty on the western slope, which is everywhere the most precipitous. In descending the western slope of the Rockies by the Kicking Horse Pass (the most southern available one), the line is transferred from Bow River by ascending one of its tributaries about three miles in length to its source—which is a marsh on the line of the continental divide, from which the water at flood time flows in both directions. This marshy summit is 5,300 feet above tide, and the pass is therefore without cutting or tunnel, as well as without a snowshed. Eastward of this point of departure from Bow River there is no grade to Atlantic tide water exceeding one per cent., but immediately after crossing the summit, the heaviest grade on the whole line is encountered, four and one-half per cent., upon two stretches of three and one quarter miles each, with a three-mile ease between. This is upon what is called "the temporary line," a deviation for nine miles from the contract location (which only permitted half this grade), in order to descend sooner into the bottom of the valley. The contract location is upon the precipitous face of Mount Stephen, underneath an adjoining glacier, and involved tunneling, increased cost, time, and delay in opening the line. There is a temporary curve as well as grade in the Kicking Horse Pass, which was caused by the collapse of a short tunnel from clay expansion. The curve is 23 degrees and is worked by all trains without difficulty at a speed which does not draw attention to the radius. The question will now be between fighting it out on the tunnel line or avoiding that by a double crossing of the Kicking Horse River.

All the gradients on the Canadian Pacific Railway which exceed one per cent. are concentrated upon the 134 miles which lie between Bow River, three miles east of the summit of the Rockies, and a point one and one-half miles west of Albert Canon on the Illecillewaet in the western slope of the Selkirks.

The railway route is nearly due west, but the Columbia River, where struck by the Kicking Horse, flows northward to the 52d parallel and there doubles, returning southward and inclosing in this oxbow the formidable Selkirk range of mountains, over which as yet no trail had been discovered. The distance across this range, in the direction aimed at, was less than one-third of that following the river around it, and therefore strenuous efforts were made to discover a pass, which, after repeated trials, was effected by Major Albert B. Rogers, M. Am. Soc. C. E., an American engineer. This Selkirk crossing, the summit of which is 4,300 feet above tide, penetrating a previously unexplored region, is one of the few cases in which the locomotive has preceded the Indian in the formation of any kind of trail.

The Selkirk crossing does not show heavy grading for a mountainous section. Its cost is in its structures over and under the track, which are called for by the snow question alone. Strong and costly sheds are required to meet the avalanche, and large and costly bridges only to get out of the way of it.

* Address at the annual convention of the American Society of Civil Engineers, at Milwaukee, Wisconsin, June 28, 1888.—*From the Transactions of the Society.*

THE SELKIRKS.

When the last spike was driven in November, 1885, no provision had been made for working the line through the mountains during the following winter. For construction purposes the rails had been laid as rapidly as possible, and the approach of winter suspended completion; but engineers were left behind provided with meteorological instruments, snow shoes, and dog trains to determine the position, character, and extent of the snow sheds. The result of this first winter's inspection was the construction in the following summer of 35 snow sheds, having a total length of four miles. The next winter, the first in which the line was opened for traffic, demonstrated that more sheds were needed, and that existing ones required lengthening in some cases, strengthening in others; that parapets over the portals, and glance-works on the mountain side above, were needed to direct sliding snow over the sheds instead of between them. During the summer of 1887, the total length was increased to six miles, and the total number to 53. The experience of the past winter has shown that additions to the sheds are required to the extent of about 4,000 feet, bringing up the total length to about seven miles. The 53 sheds already erected embrace several types, the primary distinction being, first, those designed for snowfall alone and those exposed to avalanches; and, secondly (as between these last), those exposed to the avalanche on one side only and those exposed to it upon both sides. These last are called valley sheds, are flat-roofed, and cost about $66 per lineal foot. The typical shed of the Selkirks is an avalanche one, with solid rock-filled crib-work upon the mountain side and strongly braced framework for its outer wall. The cost of these ranges from $40 to $70 per lineal foot, according to location, the increase being due to the greater mass of crib-work required where the avalanche is heaviest. The space between the crib-work and the mountain side is filled in so as to conduct the avalanche over the roof of the snow shed, without striking heavily against it. The second important type is the gallery shed, which is without crib-work, but has its roof extended against the mountain side upon strong frame-work. The cost of these ranges from $15 to $40 per lineal foot.

A combination of the typical and gallery sheds is where crib-work is used as a foot wall on the mountain side. This is called "toe crib and gallery" shed, and costs from $27 to $54 per lineal foot.

The gallery sheds are generally extensions of the typical sheds on the flanks of the avalanche and outside its path, and where necessary are terminated by strong parapets as much as 10 feet high to prevent the overflow of the lighter snow from the wings of the avalanche. By means of these parapets 40 to 50 feet of shedding at each end is saved; and the same principle is adopted where slides come down narrow ravines, in which case the profile of the roof is a trough the width of the ravine. These are called "scoop sheds."

During the summer of 1886, fires denuded the mountain sides, leaving no support for the snow on steep side hills, increasing the number of slides and the demand for shed extensions. Sheds were lengthened at each end and connected together until the longest shed exceeded 3,000 feet. Long sheds are objectionable, not only on account of the greater fire risk in summer, but in the handling of long freight trains on the heavy grades during the winter, when the sheds are entirely dark from snow fall and snow slides. The egress of smoke is then prevented, and brakemen are unable to see signals or hear whistles. In order to limit the length of sheds, and maintain as many breathing holes as possible, a system of glance-works was devised for the purpose of protecting the necessary openings between sheds. These "split fences," as they are called, are erected on the mountain slope above the track, and are constructed of crib-work or piles, or both. They are triangular in plan, with the apex pointing upward, and on the center line of the snow slides. From the solid triangle which splits the slide, wings are slightly curved and extended, until they pass the line of the shed portals, thus dividing the slide and diverting its course right and left over the sheds. Where there is danger of the snow filling up and overflowing this "split fence," a similar one is placed higher up to cover it. Where only necessary to protect one portal, a glance fence of triangular bents, sheeted with plank, and firmly braced at the back, is planted diagonally with the track, and terminated in strong crib-work at its lower end.

The first winter's experience, founded upon close observation of the character of the slides, proved most valuable in determining the location, design, and strength of timber in the two miles of sheds built the ensuing summer; and by the adoption of wider bents, smaller sized square timber and the more extensive use of the fine round timber, adjacent to the line, for posts and braces, much economy was effected.

The sheds are almost entirely built of cedar, but planking and timbers exposed to transverse strain are of the stronger Douglas fir (Oregon pine) so abundant in the mountains. The cedar in face of heavy cribs is 12 inches square, of lighter "toe cribs" 12 × 10 inches, the back 12 × 12 inches, flatted or round, with 3-inch spaces between the courses. Ties are round, and where the bents are five feet centers, break joints in crib-work in every 10 feet, being dovetailed to the front courses and also to the back flatted timber ones. The saddle joint is round, and the entire timber-work drift bolted together. Dowels are put in foot of plumb posts where gallery is upon toe crib. The joint at the meeting of rafter, plumb, and batter posts was, in the first work, so framed as to leave a space for air between the planking of the roof and that on the batter posts; but it was found unsuitable, because the snow in a slow traveling slide found its way to the track. The joint, as shown in all the drawings, is now used, although not as strong as the first one: the air space is covered by extending the roof, and is kept open until the heavy slides come, when all spaces are securely closed. On this account it is desirable to have the sheds as short as possible, and in view of the success of the split-fence system, suggested by the Vice-President and General Manager, Mr. W. C. Van Horne, it is probable that the longer sheds will be cut out at suitable points, and the openings covered by the split fence.

The Telegraph.—Where sheds are in close proximity, an underground cable is used to secure communication with headquarters in any event, and also promptly to locate the site of any interruption. At isolated sheds

and suspected points, very high poles carrying the line clear of all probable obstructions are employed. The only interruption last winter was caused by wind storms, and the loss of time without communication did not exceed four hours.

Fire Protection.—There is a very complete system for fire protection in the Selkirks, stationary and locomotive, gravitation and pumping—stationary for sheds, and locomotive for bridges, buildings, timber, tie and wood piles and forest fires, as well as for the sheds. Water by gravitation is abundant, and flumes are erected on the roofs of isolated sheds, and supplied with running water from the nearest stream, barrels and ladders being placed inside. Where sheds are closer, pipe lines are laid with stop valves at each portal and tanks between, so that damage to pipe in one shed would not affect another. The same system applies to the longer bridges. For smaller ones the usual stationary barrels and buckets are provided.

For the locomotive and pumping system, tanks of 6,000 gallons are kept on flat cars at sidings. Each engine has hose connected with the injector by a globe valve, and can draw from the tender or the portable tanks.

For further protection against forest fires, sand and gravel is dumped from a train around bottom of bridges, trestles, etc.

Where avalanches are expected, the line is thrown well into the mountain side, and the shed roof (which by law must afford a clear headway of 21 feet above the rails) is conformed by back filling as nearly as possible to the mountain slope. Where it cannot be thrown in far enough for this purpose, a broad bench of natural ground is left to take the impact of the avalanche, and send it at a tangent to the roof of a comparatively light shed. When the ravines are too deep to be filled up, the line is thrown out as far as possible, the ravine bridged with a clear span, the abutments being protected by a glance crib and split fence, and a highway is made for the avalanche to pass under the track.

At the longer sheds an outside or summer track is maintained, both on account of the scenery, which is grandest in the shed region, and also to reduce the risk of fire.

In the 31,954 feet of sheds erected there were used 25,000,000 feet B. M. of sawed material and 1,140,000 lineal feet of round timber; and the cost of these, including the necessary changes of line to provide for them, of filling in gulleys on the mountain side opposite them, and other work of snow protection, has reached about $2,900,000, and it is proposed to expend about $200,000 more to complete the system.

The sheds were subjected to a very severe test in the winter of 1886–87, which was more severe than any observed before or since, the snowfall being the heaviest recorded, exceeding 35 feet at the summit in the Selkirks. Eight and a half feet fell in six days, and for about three weeks snow was falling almost continually, and slides during this period were very numerous and constant. The sheds proved strong enough in every respect, although subjected to the weight of snow 50 feet deep, weighing 30 pounds to the cubic foot.

The warm Chinook winds and winter rains, followed by frost, thirty degrees below zero at times, make the snow very heavy. It has been repeatedly weighed, and varies from 25 to 45 pounds per cubic foot, the latter kind being compacted in masses of 5 to 15 cubic yards, and looking more like ice floes than snow balls.

Before the snow sheds were erected, side cuttings on the slopes exposed to slides were obliterated by the latter, and the *statu quo* of the original snow slope was restored. The snow, which generally brought rocks and trees with it, was packed by the great pressure of the slide so as to be nearly as hard as ice. Black powder was found to work admirably in the side hill cuts—huge masses being blown down the hill—and the remainder, in heavy blocks, was rolled over the side. In through cuts powder was used in heavy charges to break up the snow which was too hard for shoveling, except near the top. Picks and specially designed ice chisels were here used, and the cut was benched out, entailing a large amount of labor in casting.

One cutting, about 40 feet deep, was full of trees, and presented such a peculiar appearance after being gulleted for the passage of trains, that it received the name of the "Plum Pudding."

The force of some slides was shown by the experience of a valley or double crib shed exposed to them from both sides, the unfinished lower side of which was left without the batter post and sloping sheet of plank. When struck on this side, the crib, though filled with stone, was knocked a foot out of plumb, causing the rafter to buckle, the roof being torn off and carried 200 feet up the steep slope above the track. The inside of shed was filled up with snow, which was piled 30 feet deep above it. When clearing out the shed, spaces large enough for a man to go through were found at several points, evidently the effect of confined air, and indicating the rapidity of movement which prevented its escape. Further evidence of air compression was found in the spaces between the wall timbers, which were calked with snow so hard that no impression could be made upon it without using a pick. It is a question in this case whether the roof was torn off only, or partly blown off by air concussion.

The sheds exposed to the descent of heavy trees, ice or rocks have the roof double planked, with intermediate rafters and posts. A rock slide of 100 cubic yards passed over one of these, leaving a specimen rock measuring 128 cubic feet, about ten tons, on top of the roof. In this case the slope of the ground above coincided very closely with that of the roof, exposing the latter only to a rolling load.

The snow slides vary in intensity from the quiet descent on the slope to the rushing avalanche, bearing rocks and trees, and accompanied, as it always is, with a terrific cyclone more dangerous than either. They sometimes bring down a quarter of a million cubic yards, and are governed by the moist or dry condition of the snow, by the varying slopes of the mountains, the presence or absence of trees, and of sloping crests many thousand feet above grade in the region of eternal snow and of maximum precipitation.

The avalanche is "made up" by excessive snowfall 4,000 to 5,000 feet above the level of the track, and "pulls out" over the sloping surface of a glacier, or of old packed snow of the previous winter, until it reaches the steep grade (in some cases at an angle of seventy degrees), and then there is a roar, a crash, a flying scud of snow, and all is over. Its maximum velocity can only be inferred from the imprisoned air spaces already mentioned, and from the force with which a tree was driven through a shed, where it penetrated the backing, the roof, and the solid rock-filled crib-work, knocking out a plumb post in its passage, and was sawn off ten inches in diameter at the face of the crib. At some points the avalanches cross the valley and ascend the opposite slope to the extent of 200 or 300 feet. Sheds on a track located over 100 feet above the valley have been struck by avalanches from the opposite side which ascended the slope, passed over them, and climbed the mountain side, 150 feet above their roofs.

Remarkable effects are produced by the local cyclone or hurricane induced by the swift avalanches. This sometimes extends for 100 yards outside the course of the solid avalanche, and is called the "flurry," because it is clouded with particles of fine snow. If the course of the avalanche is diverted by some natural obstacle, the flurry drives on in the line of original motion, snapping off huge trees several feet in diameter, at heights 50 feet or more above the ground, without uprooting them. Some in the vortex of the flurry are uprooted, but the majority are cut short off, as they would be by chain shot, and so far from the line of the avalanche that there is nothing to indicate the cause of their decapitation but the snow, impacted like moss against the windward side of their huge trunks. The flurry whirls upward to the height of 100 feet above the descending snow, and forward in advance of it when under full headway, presenting a magnificent spectacle to an observer at a safe distance. December last it picked up a man, and whirled and twisted him so rapidly and spirally that when dropped he was a limp mass, without a bruise or break in skin or clothing, yet with all his bones broken or dislocated.

Bridges, which have been substituted for trestles carried away by slides, are anchored by guys to "dead men" in the ravine, and thus secured have successfully resisted the "flurry," which, although it calked the chord spaces very tight with hard snow, did no damage to the structure.

With three-quarters of a mile addition to the snow sheds, Mr. R. Marpole, the experienced and capable superintendent of the Pacific division, is confident that interruption to traffic in the Selkirks will be limited to hours instead of days, as has been the case heretofore; and be chiefly the result of local damage to sheds from rocks or trees brought down by the avalanche.

The avalanche season—though a lively and brilliant one—is short in comparison with the glacier one, and when the exposed points are all protected, interruptions due to the environment will have little appreciable effect upon the general traffic of the year. There will be an exceptional item for maintenance here in excess of any other division of the road, but I believe it will be fully met by the exceptional attractions of this glacier section. The avalanche may attract hundreds of bold admirers for two or three months of winter, but for the greater portion of the year the silent, majestic glaciers, which may be approached without risk, will draw thousands of tourists into the Selkirk range, where there is no danger when there is no snow in motion.

Mud Slides.—A great deal of trouble has been experienced from mud slides and "gumbo" cuts, generally below the snow shed level in the flanks of the Selkirks, and chiefly on their western or wettest slope. In forcing track laying many slopes were left too steep; but there are cases where the angle of repose, without any provocation, has proved to be a very obtuse and inconstant one, giving rise to acute expressions of disgust on the part of the roadmaster, and affording a signal illustration of total depravity in inanimate things. In comparison, the snow slide from above is clean and respectable, but the trouble in gumbo cuts is low in origin, of vicious proclivities, and of the earth, earthy. No amount of cleaning is appreciated, and it requires to be sat upon. To effect this, the cut is deepened by steam shovel and derrick, and secured by a double row of piles on each side, 8 feet apart, the lower one (in the ditch) at 5 feet centers, the upper one (on the slope) of 3 feet centers. The inner row of piles is kept in position by a horizontal flatted sill across the track below subgrade, and the outer rows by similar but sloping braces between the tops of the inner and outer piles. A single log is run behind the ditch piles under the sloping brace, and a wall of about five logs high is carried up behind the outer row. The slopes are removed and coarse gravel is filled between and behind piling and in ditches, which permits all water to ooze through to the latter, where, owing to the grade, it readily gets away.

The "gumbo" of the Selkirk slopes is not the material called by that name in California, where it is found upon the surface of level plains, and bakes and cracks with the sun, but becomes a sticky mud with every rain. The Selkirk material is a sandy loam quicksand, and would be steady enough if it had not imbibed so much—water.

Bridging.—All the bridging in the mountain section was at first necessarily of wood, which is abundant and of excellent quality there. Some of these have already been replaced with steel. The section built by the government at the Pacific end of the road—with the exception of the cantilever across the Fraser—has wooden bridges of the Howe truss pattern. In the Selkirks there are three high bridges—154, 175, and 294 feet in height respectively. The last, the Stony Creek Bridge, is 490 feet in length, the greatest span being 172 feet, resting on wooden towers 200 feet high, standing on a concrete foundation. It is probably the highest wooden bridge in America. It is soon to be replaced with a steel arch springing from the rocky sides of the V-shaped ravine, about half way of its depth; and the other two high ones, with iron trestles. The metal bridges erected by the company, east of the Rocky Mountains, are of heavy pattern, designed by the late C. Shaler Smith, M. Am. Soc. C. E. Where through trusses are unavoidable, these have a width of 20 feet between centers.

Besides much that has been filled in, there yet remains a large amount of trestle work east of Lake Superior and upon the government section at Pacific coast, which has been substantially built and floored, as it will under any circumstances require years to substitute permanent work for them. The company has bound itself to expend the whole of the $15,000,000—interest on which is guaranteed by the government for fifty years, in consideration of the abandonment of their monopoly—upon the main line between Quebec and Vancouver. Of this amount five and a quarter millions is apportioned in the agreement to rolling stock, five and a half millions on capital account to "buildings, snow sheds, sidings, permanent bridges, filling in trestles, reducing grades and curves, and other improvements." The remaining four and a quarter millions is apportioned to "elevators, bridges, locomotive shops, filling trestles, sidings, docks, and lake and coast steamers."

By crossing the Selkirks instead of going round them in the Columbia River Valley, the road is shortened about eighty miles. The fall in the Columbia River between the first and second crossings (going westward) is 1,100 feet, an average of about 7 feet per mile. The river has its canons, and in places washes the base of the mountains, so that heavy work and possibly some tunneling would have been encountered on the longer route.

On leaving the Columbia at the second crossing, and where it soon ceases to be a Canadian river, the line crosses the Gold Range through the Eagle Pass, a remarkably favorable one, the summit being only 1,800 feet above tide, although in a range with many snow-capped mountains. There are nine snow sheds, with a total length of 1,360 feet, all on the western slope of the Eagle Pass. From the western side of the Gold Range, the line follows the shores of lakes and rivers which discharge into the Pacific Ocean upon Canadian soil. In crossing the Dry Zone or bunch-grass grazing plateau of British Columbia, there is heavy work and tunneling along the rock-bound shores of the lakes; but it is when the line descends the Thompson and Fraser Rivers, where these cut through the Coast Range, that the heaviest consecutive hundred miles on the whole route is encountered. This section, built by the government, cost about $10,000,000, or $80,000 per mile, without rolling stock or stations. There are numerous tunnels and rock cuts, as well as heavy earth cuts, and a fine cantilever of 300 feet span across the Fraser River, which was the second erection of the kind in America, and was designed by Mr. C. C. Schneider, M. Am. Soc. C. E.

(*To be continued.*)

AN IMPROVED GLOBE VALVE.

EVERY one familiar with steam fittings under high pressure knows how apt the valve seats are to become defective and leaky, caused by chips and grit being retained in the pipe, which are apt to lodge between the disk and seat, causing deep cuts, which cannot be removed by regrinding. The only alternative in such cases is to reseam the seat, an operation which can only be accomplished in very few instances. The result is that an entire new valve has to be substituted. All this annoyance and expense can be obviated by using the improved valve herein represented, which has lately been introduced by the Cincinnati Brass Works, F. Lunkenheimer, proprietor.

LUNKENHEIMER'S GLOBE VALVE, WITH PATENT RENEWABLE PHOSPHOR BRONZE SEAT.

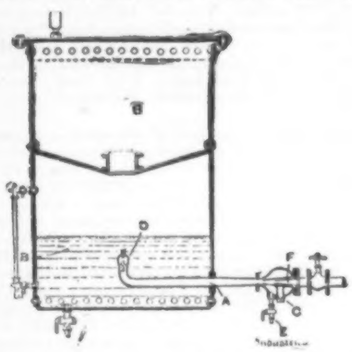
The seat and disk are made of phosphor bronze, and both can be replaced with but little trouble. The seat, A, held in its place at C by nut, B, is easily relieved, and drawn out through the neck of the globe, and a new seat substituted. Seat and disk are interchangeable, made of best phosphor bronze, and can be furnished at small cost. By this means the body of the valve will be serviceable for a very long time. All parts of this valve are substantially made, thus enabling it to withstand the most severe usage.

A FULL rigged four-masted sailing ship, named Liverpool, said to be the largest sailing vessel in the world, was launched recently from the shipbuilding yard of Messrs. Russell & Co., at Kingston, Port Glasgow, on the Clyde. Her dimensions are: Length, 333 feet; breadth, 47 feet 10 inches; depth, 26 feet 6 inches; with a net register tonnage of 3,300 tons. The vessel is owned by Messrs. R. W. Leyland & Co., Liverpool.

AIR COMPRESSOR.

A. NOSBAUME, Antwerpen.

THE steam entering through F draws in air through C, and water through E. In the pipe, A, all the steam is condensed, so that only air and water are forced through the valve, D, into the chamber, B. B is fitted with a pressure gauge and a diaphragm, which separates the water from the air, so that the chamber above

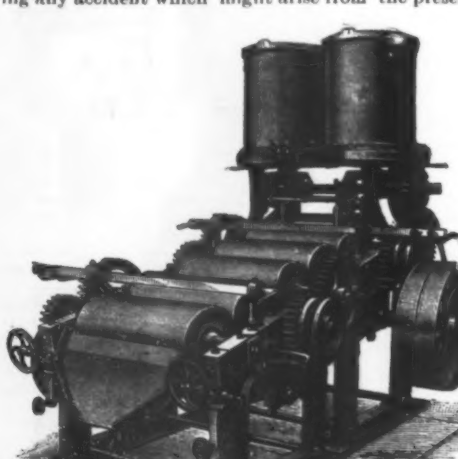


the diaphragm contains only compressed air. A blow-off cock and a water gauge are also provided.

IMPROVED PAINT GRINDING MILL.

THE accompanying engraving illustrates a new type of mill for grinding white lead, which has recently been introduced by Messrs. Follows & Bate, Limited, engineers, Gorton, Manchester. The machine is practically a combination of a pug mill and a double roller mill. Two pug mills are carried at one end of the machine for mixing the material before it approaches the rolls. While one of the pugs is feeding the rolls, the other is preparing the material; so that there is a constant supply and a consequent saving of time. The cylinders of the pug mills are 30 in. in diameter and 24 in. long, and are made of steel. The rolls are 30 in. long and 15 in. in diameter, and are made of granite mounted upon steel shafts. The rolls are in two sets of three, and the arrangements are such that the two sets may be worked either conjointly or separately. The two mills are secured together by means of wrought iron stays and lipped caps, which also afford a cover for some of the working parts.

Special adjusting wheels and scrapers have been designed for regulating the delivery and for keeping the rollers perfectly clean, and safety and adjusting springs are also fitted to the rollers, for the purpose of preventing any accident which might arise from the presence



IMPROVED PAINT GRINDING MILL.

of extraneous matter. An oscillating motion is imparted by a cam to the center roll of each set, so as to insure the perfect grinding of the material.—*Industries.*

WOODBURYTYPES.

THE late Mungo Ponton, of Bristol, in the days of the dawn of photography, discovered that bichromate of potash in contact with organic matter when exposed to light is acted upon thereby, so that a picture can be taken, an oxide of chromium being thrown down by the luminous action. Edmond Becquerel discovered the necessity for the presence of organic matter in such photographic action, but Mungo Ponton made the primary discovery at the root of so many present-day industrial photographic processes. Mr. Joseph W. Swan, of incandescent lamp celebrity, is also one who has done a great deal in devising photographic processes based upon the action of light upon the bichromates; but the one now to be described was discovered and worked out by the late Walter B. Woodbury.

A glass plate is first cleaned, talced, and collodionized in the usual way, in order that the resulting film may be stripped from its surface and printed upon from the back when placed under a negative. The plate is next coated with a mixture of gelatine, sugar, glycerine, Indian ink, and other pigments, and bichromate of ammonia, or potash; when dry, the film is stripped and exposed under a negative by the aid of an actinometer, no visible photograph to guide the operator being produced. After exposure it is attached to another glass plate coated with a thin India rubber film thrown down from a solution, and dried. The Woodbury film is laid down dry upon this surface, and "squeegeed" thereupon; it does not matter if it does not adhere perfectly at all points. The plate is then placed in a dish of hot water for some hours; the temperature is nearly that of the boiling point; this dissolves away the gelatinous pigment where it has not been attacked by light, and the light having acted upon it from the back, and penetrated it to different depths corresponding with the lights and shadows in the negative, the unaltered gelatine is dissolved off by the hot water to different depths. Thus an image in gelatine upon a tough collodion film is obtained in relief, and the ingredients are so proportioned and selected as to give as great relief as possible; the amount of coloring matter is small, to enable the light to deeply penetrate the film. By over-printing, light penetrates the whole film, and is reflected from the back surface, producing an indistinct picture. Notwithstanding the great relief of the film, there is no appreciable want of sharpness of definition in the resulting picture. The plate is next placed for two or three hours in a dish of methylated spirit to abstract the water quickly from the film, and is afterward left in a warm room for an hour or more, to dry thoroughly. When it is sufficiently dry to be removed from its glass support, it is in low relief, and exceedingly sharp; the film in the high lights is not quite transparent, but slightly opalescent if everything has been working properly.

In the Woodburytype process a vigorous negative is necessary. The thin ones somewhat frequently made in photographic studios in these days of gelatine dry plates will not give good results in the process now under notice. Such negatives should be "reproduced" in more vigorous form by copying and intensification, before employment for Woodburytype purposes. The Woodbury films have to be dried quickly, or they would deteriorate meanwhile; hence a good supply of air, dried by chloride of calcium or other special means, should be passed over them, at a temperature of about 80 deg. Fah., but not higher. In the development the temperature should be moderate at first, beginning at about 105 deg. Fah., and subsequently gradually raised. In stripping the film from the glass the India rubber comes off with it, and can be removed in little balls by laying the film on a flat surface, and rubbing with the finger. The film should then be kept for some hours before use in the hydraulic press.

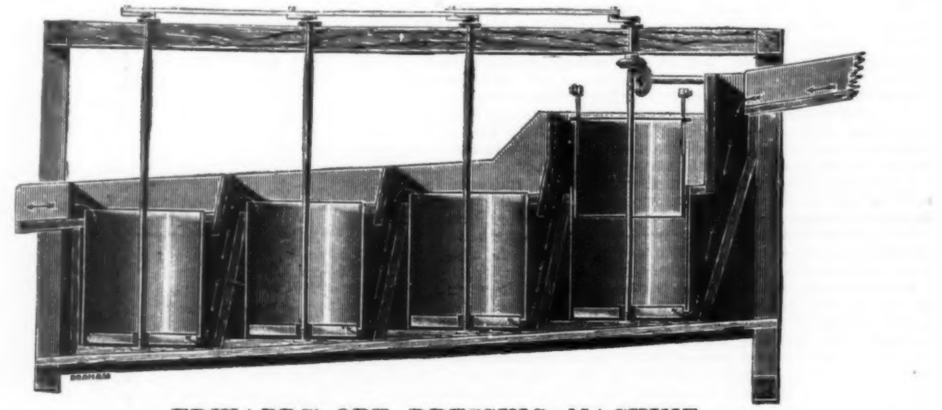
The mould to be used in the printing press has to be made from this thin skin of collodion carrying a dry gelatine picture in slight relief, and one of the chief discoveries made by Woodbury in this process was that under hydraulic pressure the image could reproduce itself in a plate of lead. The pressure is great—40 tons to the square inch being sometimes necessary; for a small picture a total pressure of 20 tons to the inch is enough. The lead is pure, and has a truly plane surface; when the pressure is applied the film lies upon a plate of polished steel, also with a truly plane surface; the steel plate is bordered by knife edges projecting a little above the surface, to prevent the lead from spreading. When the leaden mould is removed from the press, its edges are trimmed with a saw and plane, then it is ready for the press. These leaden moulds cannot be touched up by hand should they present any defects, with the exception that undue projections which sometimes appear here and there may be removed by a strip of glass manipulated by a skilled workman. Anything sticking up above the proper level of the surface of the lead can be thus removed.

These leaden moulds are embedded in a thick piece of gutta percha in the printing press, the tympan of which is of finely ground plate glass; the paper comes off the ground surface more easily that it would off polished glass. A lump of gutta percha two or three times as big as a cricket ball is rolled in the hands of a workman, then placed like a dumpling on the bed of the press, and when it cools to the right consistency the leaden plate is put upon it face upward, and the glass plate, wetted, is brought down upon it; the pressure upon the gutta percha is carefully regulated by means of screws, and the whole then left to get cold. The least bit of grit on the face of the gutta percha would be felt in working. The pressure upon the soft gutta percha and the plate is regulated according to the subject, for a picture presenting deep shadows requires greater pressure than one of the opposite kind. The ink used in the printing consists of a five per cent. warm solution of gelatine holding permanent pigments in suspension; Indian ink and carmine are the principal colors used, indigos and some of the madder browns are also employed when required; by mixing the various colors any desired tone can be obtained.

In producing Woodburytype prints Messrs. Waterlow use the finest Rive paper, weighing 10 kilogs. to the ream; this paper is, before use, specially prepared by being dipped sheet by sheet in a solution of shellac in borax, and allowed to dry; next it is rolled between steel plates in powerful presses. By these means a fine surface is obtained, and the paper is made less absorbent of aqueous liquids. In the printing a pool of the warm gelatinous ink is poured upon the mould from a bottle, pressure is then applied, and the surplus ink squeezes out over the edges of the picture; the pressure has to remain on the print for five minutes, hence six presses are mounted upon a revolving table, so that the operator without shifting his position can ink six lead plates in succession; when he has done the last one, the first has had its five minutes' pressure, and the print can be removed from the press. A moulded design, all hills and valleys like a relief map, is then upon the paper, which shows through of a pure white color in the deepest valleys. The prints are next dipped for ten minutes in a bath of common alum, strength about 10 grains to the ounce; the alum not alone renders the gelatine insoluble in hot water, but renders it less liable to decay by long exposure to atmospheric influences. The prints are then racked, face uppermost, upon canvas screens, until they are dry. Next they are trimmed and moulded by girls upon card or paper, like any other pictures which require mounting. When dry they have lost their relief appearance, and look as flat as any other pictures, the gelatine having shrunk to almost nothing, as the result of drying.—*The Engineer.*

IMPROVEMENTS IN ORE DRESSING MACHINERY.

IN no other branch of engineering has so much been attempted, and so little accomplished, as in that which deals with the preparation of metallic ores. The number of patents granted within the last twenty-five years is surprisingly great, if we group together all those which relate to inventions having for their object the more effective or more economical treatment of such ores. Yet very few of these new or improved machines are to be found in common use after they have been subjected to the test of two or three years' actual practice. The difficulties to be overcome in designing a machine of this character are very great, as there are numerous conflicting conditions to be fulfilled. The machine must be capable of performing the work required of it efficiently in all circumstances. To do this it must be simple in construction, strong, and easily repairable in case of wear and mishap. Nowhere certainly are these conditions so necessary of fulfillment as in the rough work of mining. The machines are legion which have failed to make good their claims because they were wanting in one of these points. Moreover, it is always desirable, and in most cases necessary, that the use of such machinery should not involve the employment of skilled attendants. These and many other



EDWARDS' ORE DRESSING MACHINE.

conditions which will at once suggest themselves to those who have had experience in the preparation of more than one kind or class of ores, are not to be easily satisfied. In this fact, which forces itself painfully upon the consciousness of every inventor before he has been long occupied with the problem of economically extracting metals from their ores, lies the explanation of the small success yet achieved in certain stages of the operation.

Bearing in mind these difficulties, and having been taught by a pretty wide experience in these matters to distrust appearances till they have been proved to be real by actual practice in different circumstances, we hesitate to describe Mr. Edwards' wet sizer and separator as a completely successful outcome of a bold attempt to solve a difficult problem by novel means. But we admit our inability to discover any weak points or shortcomings in the machine which was exhibited recently at the works of Messrs. Bateman & Co., of Greenwich. To all appearance, it fulfills in every particular the conditions to which a contrivance of that character is subject; and if this appearance be true, it constitutes a distinct advance in the practice of ore dressing.

Mr. Edwards' machine for the treatment of auriferous and other ores is, as its name implies, a "sizer" and separator of the crushed material as it comes from the stamps. The great advantages of "sizing" or separating, according to their dimensions or relative specific gravity, the particles of crushed ore, as a preparation for successful concentration, are known to all mining men; but in very many cases the operation is omitted, because the apparatus hitherto available for that purpose very often fails to give satisfactory results. That Edwards' machine will work effectively there is no doubt. That it will work rapidly is equally beyond question. In the course of the demonstration at Greenwich the other day, 2 cwt. of stuff was successfully treated in ten minutes—a rate of work that may be fairly estimated at 6 tons a day of twelve hours. Compared to this output, the machine is of remarkably small dimensions. It consists, as will be seen from the above illustration, essentially of three or more short vertical cylinders, set in line upon an inclined plane, and constructed to receive from below the water containing the mineral substances in suspension. The cylinders are provided with stirrers or agitators, to prevent a too rapid deposit of those substances. The agitator in the first cylinder, which retains the heaviest particles, revolves slowly; that in the second cylinder has no continuous rotary motion, but oscillates through a quarter circle, and that in the third cylinder

oscillates through one-eighth of a circle. Thus the degree of agitation diminishes, like the dimensions of the particles of mineral in suspension, from cylinder to cylinder. The power required to give motion to these agitators is very small.

To understand the action of this machine, and the principle on which it proceeds, let us start with the assumption that all the cylinders in series are full of the water, bringing with it from a small chute or trough above the minerals to be sized and separated. As the water has passed from one to the other, each cylinder will contain different grades relatively to the rest, and in each, individually considered, there will be a gradation of the particles according to their size and specific gravity, the lighter particles being toward the top. As they have been in agitation a sufficient time to give a proper separation, it is now required to remove the upper portion of the water—to a depth of 12 in.—in each cylinder. That in the last of the series is to be discharged into the "tailings" receiver, while that in each of the other cylinders is to be passed on to the next. In this way the circulation is kept up, the discharges taking place about once a minute. As we have already said, the cylinders receive their water from below, so that the water which is discharged from the top of one is introduced through the bottom of the next in series. The transfer is effected very ingeniously, and the operation is brought about by the following very simple means.

In order to obtain a head of water wherewith to start the series of pulsations which effect the changes, the first cylinder has telescoping within it another cylinder, open at both ends, and capable of being raised by a hand lever to a height of 12 in. Expressed in another way, when this telescoping part is drawn out, the first cylinder of the set is made to be of greater capacity than the rest by increasing its height 12 in. When full, the sliding part is rapidly lowered, and the overflow passes away to the bottom of the second cylinder, from the upper part of which it displaces an equal quantity of water. This, flowing over the top, passes away in like manner to the third cylinder, and so on till the tailings receiver is reached. The loss of head due to friction causes the pulsation to decrease in violence from cylinder to cylinder, so that the action is strictly in accordance with the conditions prevailing in each cylinder. These sizing cylinders are each provided with a valve at the bottom for the discharge, at intervals, of the deposited minerals. In the trial made at Greenwich, Mr. Edwards exhibited a novel and efficient form of buddle, set beneath the sizing and separating machine to receive conveniently the products of the latter.

THE INVENTORS OF PHOTOGRAPHY.

WHEN, in a science such as that of photography, a rapid progress is made, there is a tendency to walk ever onward and onward, without casting a glance backward, and to rush from discovery to discovery. We sometimes even forget the names of those who were the early pioneers, who entered an unknown path without the guidance of any previous labors, who obtained the first results, and who even foresaw the future consequences of the latter, but were unable to be lookers-on at the realization of their dreams.

As for us, who, through the labors of our ancestors, thanks to the heritage of facts and information that they have bequeathed to us, have been enabled to acquire results perhaps more important, but with more facility, let us not forget how great a share is their due. Let us stop a moment to admire them and then to study them.

In this century, which will be the age of steam, electricity, and photography, progress succeeds progress so rapidly that many facts, made known a long time back, remain ignored, although they might be put to profit. Impracticable or not utilizable at the epoch at which they were made, certain inventions are capable now of rendering the greatest service.

We are going to do some retrospective work as regards photography, and the reader will certainly be gratified to see, among early discoveries, those that have survived, those that have had but an ephemeral

FIG. 1.—MONUMENT TO NICEPHORE NIEPCE AT CHALONS-SUR-MARNE.

duration, and, finally, those that, after a period of rest, are to be developed anew as a consequence of the recent progress made.

As long ago as the sixteenth century, the property of silver salts of being influenced by light was pointed out by G. Fabricius. This alchemist had remarked that *luna cornea* (the name given at that epoch to chloride of silver) was blackened by light.

Scheele took up these experiments later on, and proved that the sensitiveness of this product was not the same under the action of the different rays of the solar spectrum.

Senebier, in 1782, Ritter, in 1801, and Berard, in 1812, studied this same question, and, after the labors of these men, it was possible to admit, with certainty, the existence of actinic and non-actinic rays.

This discovery is momentous, for it permits of manipulating sensitive preparations without danger

FIG. 2.—MONUMENT TO DAGUERRE AT CORMEILLES-EN-PARISIS.

by the use of a non-actinic light, but it shows one of the great defects of photography, and one to whose consequences we are always subservient.

Various objects, according to their color, will be absolutely different from the standpoint of actinism. While some will be produced with the greatest facility, others will not be, except at the cost of the most serious difficulty. If, as in a landscape (and this is the most ordinary case), they are mixed, we shall experience obstacles in the way of reproducing them in their relative value that are, so to speak, insurmountable. So we cannot too greatly encourage the studies of Vogel and Tailfer, the object of which is, by the introduction of certain substances into the photographic film, to render it equally sensitive to the various rays. The results already obtained in this direction seem to prove that the non-actinism of certain rays of the spectrum will not always be an obstacle in the way of their reproduction.

The first experiments in utilizing the properties of the salts of silver for the obtaining of images were made by the French physicist Charles, who, in 1780, in his lectures, reproduced silhouettes upon a sheet of paper impregnated with chloride of silver. The source of light employed was a fascicle of solar rays. Davy and Wedgwood continued these experiments in England, but we have to come up to 1844 to find the first image made in a camera. Joseph Nicephore Niepce busied himself with this important problem, and received the image upon a metallic plate covered with a thin layer of bitumen. The latter, in the high lights, becomes insoluble in its usual solvents, while it remains soluble and disappears in the other parts. The image that appears is formed partly by the exposed metal and partly by the bitumen rendered insoluble. This process was a very long one, and required no less than from ten to twelve hours' exposure in full sunlight. But it is undeniable that Niepce's experiments gave the first photographic image.

Niepce used the same reaction for obtaining plates by placing the bitumen-covered plate under an engraving or drawing rendered transparent. It will be remarked that Niepce's processes, greatly improved, are now in constant use in the art of printing.

Daguerre, too, occupied himself with the same problem, and he and Niepce were brought together through Charles Chevalier, a well known optician. In 1829, these two inventors worked their processes and made their researches conjointly. It is absolutely unknown what the result of this partnership was, which was abruptly terminated by the death of Niepce in 1833. Daguerre pursued his studies alone, and these resulted in the universally known process which bears his name—daguerreotype. It must not be forgotten, however, that Daguerre had had full communication with the labors of Niepce, and that the splendid discovery to which he gave his own name solely was at least inspired by Niepce's ideas. Nobody had any doubt of this, and it was with satisfaction that, upon the proposition of Arago, people saw a national recompense decreed to the inventors of photography—Daguerre and Isidore Niepce, son of Nicephore Niepce and heir to his rights.

The noise made about Daguerre's discovery caused the labors of a certain modest worker to be nearly forgotten—those of Mr. Bayard, who, previous to the discovery of the daguerreotype, had obtained and even exposed negatives formed directly in the camera. His process, however, is essentially different from Daguerre's, and, although he did not divulge it at an opportune time, it would be unjust not to mention it.

The same year, Talbot, who was following up the researches of Wedgwood and Davy, gave some methods founded upon the use of chloride of silver, showed how to fix negatives by iodide of potassium, and pointed out that other things than the vapor of mercury could render the image developable.

These are discoveries of the first order, but there are others which, although less important from a theoretical standpoint, have been followed by great practical consequences and must not be passed over in silence.

Thus, in 1839, Herschel pointed out the use of hyposulphite of soda for fixing images. This salt is still in daily use in photography, and there is nothing to make it foreseen that it will soon be replaced. In 1848, Niepce de Saint Victor, nephew of Nicephore Niepce, proposed glass as a substratum for the sensitized film.

As we have just seen, the efforts of researchers were especially directed at first to the obtaining of an image in the camera—Niepce, who obtained the first image; Bayard, whose original process obtained but little notoriety; Daguerre, who found the latent image and the daguerreotype; and, finally, Talbot, to whom we owe the first negative.

Among those who have occupied themselves with the production of the positive image obtained from the negative, we shall mention one whose name, little known outside of the world of photography, dominates all others through the importance of his labors and the prolific results that have been the consequence of them; we mean Poitevin. It is to him that we owe the complete study of the reaction of bichromated gelatine—a study whence have resulted the various processes of printing now so much employed, such as phototypy, photoglypty, photographic typography, etc. It is he, too, who indicated the use of gelatine as a substitute for collodion or albumen for the obtaining of sensitive films. No one ignores the fact that it is this substance which, in combination with bromide of silver, composes the gelatino-bromide plates whose truly wonderful rapidity has permitted of an unlooked for development in the application of photography to the various sciences.

France, with which no one can for an instant dispute the honor of the discovery of photography, has endowed the civilized world with it by purchasing from the first inventors processes that might have remained unknown to the public. But she has done still more: at the instance of eminent persons of the photographic world or learned societies, she has erected monuments to these makers and researchers in order to prepetuate their memory.

Now that we can more justly appreciate the importance of the results that have been the consequence of their discoveries, we shall express one regret, and that is that these monuments have not, all of them, the importance desirable. But, as we know, the discoveries of science are not those that make the most noise, and that are the best recompensed; the results are not always immediate, and the poor inventor is often already forgotten when we daily perceive the greater and greater results of his work.

We place before our readers reproductions of the monuments erected to our French compatriots. Let us hope that our neighbors across the channel, who are great admirers of photography, will not forget their countryman Talbot.

Let us now see what remains of these different discoveries. Niepce's process was not practical, and would not be any more so to-day, on account of its excessive slowness; but this inventor showed the possibility of reproducing the images of the camera. His tentatives in heliogravure were the starting point of very important processes (photogravure, zincography, etc.) which are now in daily use.

Daguerre's process no longer exists except as a historic curiosity, but what will remain imperishable is his discovery of the latent image. It has become possible to modify the processes for developing this, but all the present ones are based upon the production of such image.

Talbot, in addition to various processes of development of the latent image, gave us the negative image, which, upon the whole, is the base of photography. It is the great defect of the Daguerre process that there is but a single image and that is reversed; with the negative, the image can be multiplied to infinity, and is turned in the right direction.

As for Poitevin, whose special object was the production of an unalterable image, his work is now receiving full recognition. The various processes of which he is the father are continuously developing, and, thanks to

FIG. 3.—MONUMENT TO POITEVIN AT SAINT CALAIS.

them, photography is daily taking a more important place in the art of printing.

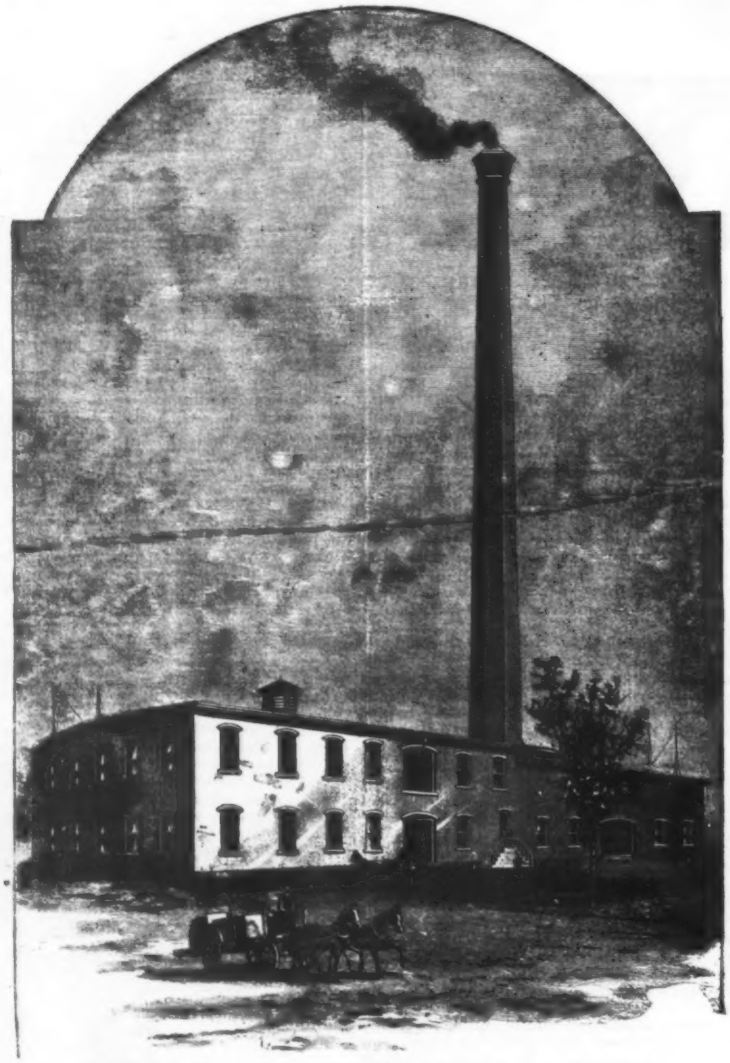
The use of glass, proposed by Niepce de Saint Victor, dethroned paper as a support, and up to recent years seemed to reign as master over it; but, aside from its planeness and exquisite transparency, it has two very

serious drawbacks—fragility and weight. Now that the use of photography has spread in all classes of society, and that its apparatus is traversing the entire world, these two drawbacks occasion much trouble and vexation, and there is a tendency to return to paper as a support for the sensitive film. It is, as may be seen, a complete return to the rear. It is true that in the interval we have acquired preparations of exquisite sensitiveness, and that the new paper has no longer the slowness of the old. It appears to us, then, as if paper is to resume an important place in photography, and is to replace glass in most cases. The use of it will necessitate modifications in the *materiel*, for it is possible to employ it in long bands mounted upon rollers, one carrying the unexposed paper, and the other the exposed.—*La Nature.*

CAMBRIDGE ELECTRIC LIGHT CO.

THE Cambridge, Mass., Electric Light Company, having found its business increasing so rapidly that its central station, located on the Charles River bridge, became altogether inadequate for meeting the demand for light and power, determined upon a new and larger station, and has erected a building and installed a plant, which is composed of the Thomson-Houston arc, incandescent, and alternating systems. It is in every respect a model plant and a credit to the enterprise of the executive of this flourishing company.

The plant of the company consists of a large brick building, containing on the first floor boiler and dynamo rooms, dormitory, store room, arc and incandescent rooms, a superintendent's room, treasurer's office, toilet and bath rooms. The boiler room is but one story high, roomy, high studded, and well lighted. It is fitted with four 125 horse power boilers, a 1,000 horse power condenser, and a 500 horse power heater. There is plenty of room for five more boilers and another heater. The dynamo room contains a 250 horse power Buckeye engine, a 100 horse power Armington & Sims engine, a 90 horse power New York safety engine, three 50 light Thomson-Houston dynamos, three 45 light Thomson-Houston dynamos, a 1,000 light and a 500 light alternating dynamo, and a 40 horse power generator. In this room there is ample space left for nearly double the present number of machines. —*Modern Light and Heat.*



CAMBRIDGE ELECTRIC LIGHT STATION.

THE ELECTROLYSIS OF COMMON SALT.

MR. N. N. BEKETOV, of Charkov, has recently communicated to one of the scientific societies of St. Petersburg the results of his experiments on the electrolysis of common salt. All the sodium products are at present obtained by the Leblanc or ammonium process, and several manufacturers have, it appears, applied to Mr. Beketov for an opinion as to the comparative advantages of these processes. Being of the opinion that neither the Leblanc nor the ammonia process was as perfect as it ought to be, Mr. Beketov determined to try electrolysis, though he had already experimented unsuccessfully in this direction some years before. This last set of experiments have, it is stated, been more promising, though they have not yet been tried on a commercial scale. The inventor sends a current through a mass of fused salt, the temperature of which is about 500 deg. Cent. In this condition it is a fair conductor, and is rapidly decomposed by the current. With an electromotive force of 5 volts and a current of one ampere, 36 lb. of salt can be completely decomposed in twenty-four hours. From this the author argues that considerable economy can be effected by the adoption of the new process.

A NEW DETERMINATION OF THE OHM.

IN the development of most problems relating to measurements of precision, we may distinguish two periods. The first, in which, after devising the methods, hasty experiments are made, less for obtaining a definitive value of the quantity sought than for getting an approximate idea of the precision that it is possible to reach, is characterized by an extreme confidence in measurements that have for a consequence a wealth of decimals in the results.

In the second, on the contrary, there has occurred a return from the first enthusiasm. A few discordant results, without our knowing exactly why, make us suspect various difficulties that we had not thought of, and that we then begin to make researches upon. It is in this second period that begins the irksome hunt for the causes of error which arise all around and exhibit themselves just where they were least expected.

One can therefore esteem himself lucky when, after months or years of labor, he has secured a precision nearly equal to that which it was believed had been attained in the first experiment.

The determination of the ohm has not escaped this general law; further, it is one of the most striking examples of the transformation that we have just sketched.

Before the International Congress of 1884, no one suspected that there was any serious difficulty in determining the absolute value of an electric resistance to about a thousandth. After the congress, this problem had acquired a reputation that was not calculated to encourage those who proposed to solve it.

Physicists then began to examine with care the advantages and defects of the various methods, and a few of them, having sufficient means at their disposal, began experiments anew upon new bases.

Among the determinations made in recent years, there are few that have been performed under as good conditions as the one made by Mr. F. Kohlrausch. We shall not endeavor to summarize the bulky memoir* that he has just presented to the Academy of Sciences of Bavaria, but shall merely extract a few data that have appeared to us as particularly interesting.

The method adopted by Mr. Kohlrausch was the "method of amortizement" of William Weber.

Up to the present, this method has given very small numbers; it was thought that it contained some hidden fault, and several physicists have striven to discover an error of principle in it.

Let us say, in the first place, that the value found by Mr. Kohlrausch,

1 ohm=1·0632 Siemens unit,

justifies, *a posteriori*, the choice of the method.

In his preface, the author gives his reason for the preference: "I had," said he, "to select for the problem proposed a method that should have been as well studied as possible, the difficulties of which were well known, and upon which my experience should permit me to have a personal opinion."

In the Weber method, the resistance is calculated by the following formula:

$$R = \frac{\pi^2}{2\tau} G^2 \frac{M}{H} \frac{\sqrt{\pi^2 + \Lambda^2}}{\Lambda}$$

G, M, and H have their ordinary significance, τ designates the duration of the magnet's oscillation, and Λ the logarithmic decrement. The constant, or rather the galvanometric function, G, is very difficult to calculate for a galvanometer of small size. Mr. Kohlrausch effected the determination by the Dorn process, which consists in comparing the galvanometer that is to serve in the experiment with a tangent galvanometer of large size placed coaxially with it. The cut shows the arrangement of the apparatus.

The large tangent galvanometer, B, consisted of a frame 5¼ feet in diameter, made of mahogany boiled in paraffin. It consisted of 48 pieces connected by screws. This frame was strengthened by mahogany stays. The copper wire made 34 revolutions.

The ratio of the sensitiveness of the galvanometers, measured by a method of zero, by bifurcating a current in two known resistances, was about 100:1.

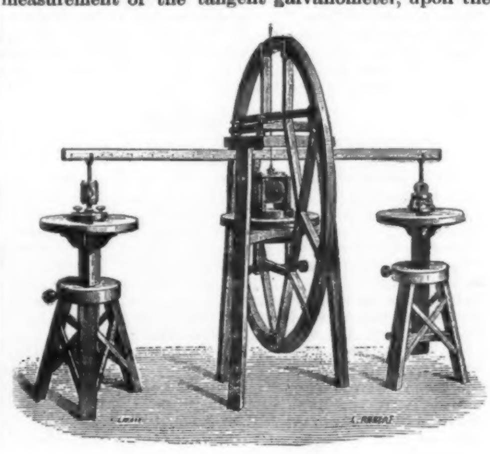
The two small magnetometers, M M, served for determining the ratio

$$\frac{M}{H}$$

The measurement of the other magnitudes that enter into the formula is understood of itself.

Let us, with Mr. Kohlrausch, examine the series of measurements upon which the determination of the ohm depends.

The galvanometric constant, G, depends upon the measurement of the tangent galvanometer, upon the



length of the needle, and upon the ratio of the bifurcation resistances.

$$\frac{M}{H}$$

contains the cube of the distance of action; in addition, the deflection of the needle, the distance of the scale, the constant of torsion, the ratio of the magnetic fields, the polar distance of the magnet and of the needle, etc.

In the measurement of τ, the variations in the declination constitute the most difficult error to eliminate.

Each of the errors enumerated is composed of several others, the total number of which, according to Mr. Kohlrausch, probably exceeds a hundred. According to this, if several of these errors exceed $\frac{1}{10000}$, it is not surprising that the results may differ from each other by several thousandths.

Mr. Kohlrausch's measurements form two independent series made in 1886 and 1887 with different apparatus. The Observatory of Wurzbourg, constructed without iron, was particularly adapted for this work. A portion of the accessory studies was made by Messrs. Strecker, Kreichgauer, Sheldon, and Heydweiller.

The measurements whose principle we have rapidly sketched were devoted to the determination of the resistance of the multiplier in absolute value. Another part of the work consisted in the comparison of such resistance with a normal standard. This comparison, within the limits of precision of which it is here a question, presents no difficulty, and we shall not expatiate upon the method employed. We shall rather give a few details as to the standards.

Mr. Kohlrausch is one of those rare physicists who, in the determination of the ohm, has not been content with the German silver copies of the mercurial unit furnished by a manufacturer. This method of procedure has certainly introduced the largest number of all the causes of error into a large number of measurements.

The mercury standard consisted of a calibered and gauged rectilinear tube whose resistance was about 1·30 ω. It was not employed directly in the experiments, and served only to verify, from time to time, the German silver standards with which the multiplier was compared. The mercury standard was constructed by Mr. Strecker.

The German silver resistances were formed of a wire 0·05 inch in diameter, wound upon a wooden cylinder. During the entire duration of the measurements, the standards remained immersed in petroleum. We have already shown that the ordinary distributions of glass cannot occasion an appreciable variation of mercury standards. As regards their practical variability, that is to say, the limits between which they may vary

* Ueber den absoluten elektrischen Leitungswiderstand des Quecksilbers.

when they are submitted to the manipulations necessary (cleaning, filling anew, etc.), opinions vary. From the experiments in which Mr. Benoit and we were associated, we have been led to the conviction that these standards are invariable, so far as the most precise experiments permitted us to ascertain. In fact, various copies of the legal ohm that had been compared with the prototypes of the Minister of Post Offices and Telegraphs constructed by Mr. Benoit remained constantly in use for several months. They were then emptied, taken apart and cleaned, and then filled and compared anew with the prototypes. The old equation was found again to within about a hundred-thousandth.

A very large number of other comparisons made between various copies entirely confirmed this result. There is no doubt, from this, that the mercury standards fulfill the most important condition that can be demanded of them—invariability.

Mr. Kohlrausch, also, expresses himself absolutely affirmatively upon this point. Such, however, is not Mr. Glazebrook's opinion. Having, with a bobbin, compared various copies of the ohm furnished by Mr. Benoit, he found that the value of one of them varied, during a series of measurements, from 1·00044 ω to 1·0008 ω. Emptied, and filled anew, its resistance became 0·9999. This difference, in the neighborhood of a thousandth, is explained, in our opinion, by the fact that in the first case the mercury contained a bubble of air or some impurity or other.

There has never anything like this occurred in the comparisons made by us, even when, in various trials, the tubes were filled in the air. For all regular comparisons they were, however, filled in a vacuum.

By what precedes, we do not mean to say that mercury standards can be considered as practical ones in the current uses of the laboratory. In the first place, they are too unmanageable, and, in the second, their coefficient of variation with the temperature is not well enough known to allow the reduction to zero to be made with certainty. In very accurate experiments, in which it is very important to know their true value, it is necessary to keep them at the temperature of melting ice.

Let us return to Mr. Kohlrausch's experiments. The most interesting result of the comparisons between his various resistances concerns the variations of the German silver standards with time. The first comparison was made twelve days after the construction of the standards. Their respective values on the 11th of February, 1886, were 1·3860 and 1·3843 Siemens unit. On the 2d of November, 1887, they had the following resistances: 1·3898 and 1·3860 unit.

The variation with time, deducted from twelve comparisons distributed over an interval of twenty-one months, is represented by the formula

$$r = r_0 (1 - a \, . \, 10^{-bt}),$$

t being expressed in months, the mean values of the constants are

$$a = 0{\cdot}00137 \, ; \; b = 0{\cdot}097.$$

When the work was finished, one of the copies was sent to England to be compared by Mr. Glazebrook with a standard of the British Association. During the voyage, its resistance increased by 0·0002.

Apropos of this, we express regret that a like comparison was not made with the standards of the Minister of Post Offices and Telegraphs.

The two series of measurements made by Mr. Kohlrausch gave the following results:

In 1886, 1 ohm = 1·06405 Siemens unit.
In 1887, 1 ohm = 1·06274 Siemens unit.

To the first series, Mr. Kohlrausch attributes the weight 1; to the second, the weight 2. He thus obtained the result that we have mentioned, viz.:

1 ohm = 1·0632 Siemens unit.

We shall terminate by citing a remark of Mr. Kohlrausch's, whence results an advice to constructors:

When a new international congress shall fix the definite value of the legal ohm, it is probable that a number will be adopted comprised between 1·062 and 1·063. If, in consequence, we adjust the German silver copies for a temperature bordering upon 10°, they will become exact toward 20°. These two temperatures are admissible for a standard of resistance, while a copy adjusted to 20° would become exact at 30°—a temperature too high for current use. It would therefore be advantageous after this to adjust the German silver copies at quite a low temperature.

We shall express but one fear on this subject: Will the German silver copies adjusted now be so still in a few years? The measurements made by Mr. Kohlrausch and many others permit us to doubt it.—*La Lumiere Electrique.*

A NEW SECONDARY BATTERY.

M. CAMILLE FAURE, the well-known inventor, has recently patented a secondary battery of entirely novel construction. In it the active materials consist of finely divided metals, compressed together and inclosed in a case of asbestos about 0·04 in. thick. This casing is, however, prepared before use by soaking it in a solution of barium chloride or of common salt, and then transferring it to a solution of a soluble silicate, which forms with the barium or sodium chloride an insoluble compound. The elements prepared as indicated are placed on some electrolyte capable of forming on electrolysis an insoluble compound with one or other of the two elements. With zinc and copper electrodes M. Faure employs potassium phosphate as the electrolyte, and the cell is "formed" by passing a current through it in such a direction that insoluble phosphate of copper is produced by combination with the copper electrode. This done, the spent liquor is thrown away, and a fresh supply of potassium phosphate substituted, after which the cell is ready for work. On closing the circuit, the phosphoric acid is transferred to the zinc element, the phosphate of copper being reduced to metallic copper again, and zinc phosphate formed. When run down, the battery can be recharged by a current in the opposite sense, which will again produce copper phosphate and reduce the zinc. The "forming" process could theoretically be dispensed with by employing phosphate of copper at first hand, but this material is difficult to prepare and manipulate, and the inventor accordingly prefers to act as described above. The electromotive force, constancy, endurance, and power of cell are as yet unpublished.

AMERICAN BLAST FURNACE PRACTICE.

WE find in the *Ironmonger* the following paper by Mr. William John Hudson (Assoc. Physical Science, Durham), lately read before the South Staffordshire Institute of Iron and Steel Works' Managers:

The development of American blast furnace practice has advanced during the past few years with rapid strides. A few notes, therefore, upon the subject may not be considered out of place, when submitted to a provincial institute such as this, where blast furnace practice is an important factor in the district in which we labor. Situated as we are, geographically, with heavy odds against us, in competition with more favored areas, it is our duty to look closely into the practice of our brethren around us and abroad, and see if any good features of their practice can be utilized at home to our advantage. With heavy rates of carriage, such as our manufacturers have to contend with, it is obvious that economy must be pursued, not only in mills and forges, but also at the blast furnaces from which the forges derive their supply of pig iron. Apart from the cost of raw material and wages, something may yet be done in South Staffordshire to reduce the cost of manufacture, so as to prolong the staple trade of the district (iron manufacture), which appears to be in some danger of gradual extinction through sheer force of competition. The secretary being placed in some difficulty in providing a paper for this meeting, I propose to lay before you a few brief notes on American blast furnace practice, with a desire to promote a discussion out of which some benefit to the practice of iron smelting may accrue. There can be no doubt that the slow rate at which furnaces are driven in South Staffordshire has much to condemn it. At times like the present, every sixpence that can be saved upon the manufacture of a ton of pig iron is almost worth its weight in gold, when every circumstance is taken fairly into consideration. We can only hope to maintain an increased volume of trade when the practice of our trade permits us to produce cheaply. One very important factor of economy is the spreading of fixed charges over a large production, whereby the cost per ton of product may be materially reduced.

American blast furnace practice teaches us a lesson in this respect, for while we are content to go on producing from 200 to 300 tons of pig iron weekly per furnace, it is no uncommon thing to find our American cousins producing from 1,500 to 1,800 tons in the same time. It is not to be expected that, with our present arrangements, we can ever hope in South Staffordshire to rival their output, yet at the same time we may learn lessons from their practice which may enable us to considerably increase and cheapen our production. Into the reasons which prompt American blast furnace proprietors to such heavy outputs I do not at present care to enter; their representatives at the Iron and Steel Institute meetings have from time to time explained them. Beyond that they hold with a force in America that would not probably exist in England, I leave them. The greatest productions are obtained in America in furnaces using coke as fuel, and with dimensions inferior to the standard dimensions in the best English practice, such as Cleveland affords. Why, then, do not Cleveland furnaces rival in production those of America? The reasons may be briefly stated as follows: First of all, the ore employed for heavy American outputs is much richer in iron, and of a different character entirely to Cleveland clay band. Secondly, the working lines of American furnaces of recent construction are more favorable to steady and rapid work than those of Cleveland. And, thirdly, the air is more highly compressed and driven in greater volume.

My reasons for comparing American and Cleveland practice is mainly to show where we may criticise and take advantage. Many men of very high standing are, I believe, frequently mistaken in regarding Cleveland practice the very best for all purposes, and it will be my endeavor to point out that Cleveland practice, so far as construction goes, would not benefit this district in the same degree, if applied, as would American practice. I shall, therefore, briefly deal with the three leading points already mentioned.

IRON ORES.

The iron ores chiefly employed in American rapid practice are magnetite and hematite, with percentages of metallic iron varying from 50 to 65. In many cases the yield of metallic iron will average over 60 per cent. on the mixture of ore used. Mr. E. C. Potter, in a paper on the South Chicago works of the North Chicago Rolling Mill Co. (*Journal*, Iron and Steel Institute, No. 1, 1887, 169), gives the following analysis of the material composing the burden of his furnace, making about 1,400 tons (of 2 000 lb.) per week, at a fuel consumption of about 1,900 lb. coke per ton of iron.

	Iron.	Silica.	Phos.	Alumina.	Lime.	Magnesia.
Hematite						
Cambria	62·88	6·40	0·03	2·68	0·36	0·04
Chapin	63·24	3·70	0·07	1·43	1·87	2·06
Cleveland	60·37	6·54	0·05	3·03	0·58	0·20
Colby	58·61	3·89	0·05	—	—	—
Norrie	63·57	4·09	0·06	1·38	0·71	0·17
Superior	62·36	4.33	0·06	—	—	—
Specular—						
Cleveland	65·08	4·22	0·11	1·65	0·41	0·18
Superior	64·55	4·26	0·08	2·61	0·50	0·40

NOTE.—Colby hematite contains also 4·42 per cent. manganese.

At the Edgar Thomson blast furnaces, of which a notice appeared in *Engineer*, April 9, 1880, the following charges of ore were, at about that time, employed on a make of about 700 tons (2,000 lb.) weekly:

	Lb. per charge.	Iron per cent.
Tafna Ore	1,900	58·65
Pilot Knob	1,900	58·69
McComber	900	52·41
Somorrostro	900	49·15

Mr. E. Windsor Richards, in a description of these furnaces, states that the ores contain from 53 to 55 per cent. of metallic iron, and are brought from Lake Superior, St. Louis, Africa, and from their own Scotia mines, the make of iron at the time being about 1,400 tons per week. Cleveland calcined ironstone rarely contains more than 42 per cent. of metallic iron. Thus, it is easy to see that ores such as are employed in the States lend themselves more readily to large makes of iron, if only on account of their superior richness in metallic iron. Not only is this so, but it has been shown by experiments conducted by Sir Lowthian Bell that ores of this superior quality are more easily deoxidized than Cleveland calcined stone—in other words, the oxygen commences to be removed at a lower temperature and at a quicker rate of progress than with the Cleveland stone. These two facts account in part for the reason why American furnaces can be driven at a greater rate than those of this country, but do not explain all. The South Staffordshire native ores, whitestone and gubbin, are richer in metallic iron, and more easily reduced by carbonic oxide than Cleveland ores, although, perhaps, not so readily as those of America, yet South Staffordshire furnaces are rarely worked with these materials over 200 tons to 250 tons per week.

SECTIONS OR WORKING LINES.

I propose now to deal with the second part of my paper, which bears entirely upon the construction and section of American furnaces. In order to bring this more forcibly before you, I shall show what may be regarded as typical sections of American and English furnaces, and endeavor to show that the American sections are more favorable to rapid working than ours, and invite your attention to the sketches accompanying this paper. On comparing the sections of English with American furnaces, the most striking feature that presents itself at first sight is that in comparison with height, the English furnaces are wider at the bosh lines, narrower in the hearths, and, consequently, the boshes are not so steep. In other words, the American furnaces more nearly approach that form of furnace which some engineers have been bold enough to suggest, viz., a cylindrical furnace, but without the disadvantages which such a furnace would inherit.

When we consider the function of a blast furnace, it certainly appears reasonable that, within certain limits, a furnace should be as nearly cylindrical as possible. The chemical reactions which have for their duty the deoxidizing of iron ore occur, or should do so if a furnace is perfectly designed, in the upper part of the structure, before the materials descend so far as to reach a region hot enough to enable the carbon of the fuel to react on the carbon dioxide (the result of deoxidization of ore), with the production of carbon monoxide by the well-known formula $CO_2 \times C = 2CO$. It is somewhat beside the subject of the paper to discuss the chemical actions which here take place, as it is my desire at present to look more to the mechanical than to the chemical aspect of this part of the paper. Not that the chemistry involved has nothing to do with the economy of the American practice when viewed from the standpoint of an engineer, for I am convinced that the lines adopted in American practice favor, to a considerable extent, the chemical economy of their practice. After the chemical actions to which I have referred have taken place, the material, or stock, as the Americans call it, descends rapidly into regions of increasing temperature, until at last it reaches a temperature of furnace hot enough to effect fusion, when the metallic iron and slag separate into their respective molten states, and fall into the hearth or crucible of the furnace. It must be obvious to all that as little obstruction should be offered to the uniform descent of stock as possible. This condition appears to be best provided for in furnaces where the diameter of bosh is not extravagantly greater than the diameter of the hearth beneath it, and the stock line above it, near the throat of the furnace.

In the first place let us consider the descent of stock. If the proportion of charging bell to stock line is such as will give a satisfactory distribution and mixing of material, then as little disturbance of this arrangement should be allowed in descent as can be governed. Now, if the diameter of bosh is much greater than that of the stock line, the descending stock will ever be shifting itself into areas of increasing dimensions, until the bosh is reached. This might be obviated, say some, by making the lines above the bosh parallel, but if we consider the nature of the changes, due to temperature, the stock undergoes in its descent, we shall soon see that a parallel structure is mischievous. Consider for one moment the stock to be a series of disks one upon another, and of considerable density, descending in a cylinder. As soon as the lower disks become sufficiently hot to be somewhat soft, they will, like an India rubber disk under a vertical pressure, flatten and expand outward. The result of this in a blast furnace is that the pasty material will jam against the side of a parallel structure, the central portion will be thrust down by the weight above it, the ascending hot gases will find their way through the center, leaving the outside to gradually cool and form what is known as a ring scaffold. A structure with a proper amount of taper down to bosh level will not give this trouble, because as the disks become soft, as just described, they are descending into greater areas, and become detached from the sides of the furnace in consequence, which allows a free passage through the whole mass for the ascending hot gases. This result maintains the whole of the descending stock at this critical point at a fairly uniform temperature.

Now, with regard to the action of the ascending gases in the two types of furnaces we are considering, viz., the English, with its small hearth and wide bosh, and the American wide hearth and slightly wider bosh. I shall not now deal with the furnace parallel above the bosh, for I consider its worst influence is upon descending stock. In the English practice the blast is delivered well toward the center of the furnace, where it will then have to expand and diffuse considerably if an excess is not to creep up the center of the structure, leaving the sides a deficiency. This is, as a rule, what occurs in our practice. We have what might be termed a central blower of rich, hot gas, more than enough to heat and chemically affect the portion of stock with which it comes in contact, causing rapid central action, but leaving the outside stock to more slowly descend in an imperfectly heated condition. Not only so. The outside stock, under such conditions, will probably de-

scend into a red hot region before complete deoxidization has taken place, when, of course, the wasteful action of red hot coke upon carbon dioxide will occur. The conditions just described undoubtedly favor the formation of ring scaffolds, which not only materially reduce the effective cubical capacity of the furnace, and thereby increase the consumption of coke, but are most troublesome for other reasons, and most difficult to discover and remove. Extremely wide boshes do not permit a proper distribution of gas with stock, and, where such a condition exists, the only remedy we have is to draw back the tuyeres, which makes a wider hearth, cuts away the lower part of the boshes, and enables the ascending gases to permeate the outside portion of the stock. Such has frequently to be done in English furnaces before satisfactory results can be attained. The American practice of making the hearth wide to begin with, and keeping the diameter of bosh within a reasonable proportion to the hearth, gives great advantage. A glance at the diagrams of the Edgar Thomson, Chicago, and the Franklin furnaces, of America, will convince one at once of this fact. Another feature of American practice is the tendency to keep the bosh low. The nature of this will be at once seen on inspecting the lines of the Franklin furnace. From what has already been said about the formation of scaffolds, particularly of ring scaffolds, it will be apparent that if the taper usually given to the interior lines of a furnace is carried low enough to be well beneath the point at which fusion commences, the tendency to scaffolding must be materially reduced, for when the bosh line is reached the solid material will consist entirely of fuel, while the fused material will have become sufficiently fluid to be beyond the influence of an ordinary chill, to which furnaces are at times liable, and will therefore rarely be chilled sufficiently to become again pasty or solid. I find in this district a tendency to recede from the practice of some years past of raising the height of bosh in order to secure a steeper angle. Managers are paying more attention to the lines which a furnace will develop of its own accord. A steep angle of bosh is not in itself all that should be desired. Let the bosh be steep if you will, but at the same time do not carry the height of bosh too high. If the bosh, for any reason, must assume a flat character, by all means keep its greatest height well down. For my part I would rather work a low, flat bosh than a steep one running high up into the furnace.

BLAST PRESSURE.

The Americans have, in many instances, the advantage over us in pressure of blast. While we are content to work with from 3 to 4 lb. pressure upon the square inch, it is no uncommon thing to find, in America, pressures of 8 to 10 lb. The stock argument against increasing our blast pressure, viz., that rapid driving will not give time for the proper preparation of material, is disproved by American practice. There is no doubt that in English practice rapid driving does tend to throw a furnace off its load, with a tendency to produce a harder grade of iron, and gobb, but the fault lies with the shape of furnace, which is not adapted to allow the material a fair opportunity. With enormous wide boshes and comparatively small hearths, rapid driving tends to accelerate the descent of central material, without a proportionate increase in the rate of descent of outside material; and, as has been before mentioned, a central action of gases means that more gas of reducing property passes through the central material than is necessary for its reduction and heating; consequently, the gases pass off at the throat of the furnace more highly heated than they should be, and with a higher percentage of carbon monoxide than is normal. I need hardly tell you such a condition involves waste of fuel. The wide hearth and proportionate bosh of the American furnace permits a more uniform descent of material and ascent of gases, whereby the whole of the material is properly reduced and heated. The gases do the maximum amount of duty, pass off at a low temperature, and with a comparatively low content of carbon monoxide. The Americans, therefore, by virtue of the shape of furnace, are enabled to carry a higher pressure of blast and produce a larger amount of iron in a given time than can be achieved in this country. At the same time, with these conditions, and with furnaces of comparatively small cubical capacity, the fuel consumption is remarkably low. In many cases less than a ton of coke is employed in smelting a ton of pig iron, and rarely more than ton per ton in furnaces such as I have described. There are one or two other features of American practice which cannot fail to be of interest to us.

First, nearly all American furnaces are worked on the closed hearth system; that is, the hearths are built perfectly circular, and have tuyeres placed all round at uniform distances from each other. Between two of these tuyeres, and at some 18 inches to 2 feet below them, an opening is provided into which a bronze nozzle is fixed, through which the slag is allowed to flow from the hearth. At castings no time is lost in having to repair and refettle the slag outlet, as is the case in the English furnaces, where the old-fashioned open fore hearth is still in existence. I have known frequently 25 to 30 minutes spent in these repairs in South Staffordshire at each cast, apart from a certain amount of blast easing during the shift, where the practice of fire throwing is in existence.

Secondly, nearly all American furnaces are provided with bronze tuyeres, which have been found to be very durable. Bronze is desirable, inasmuch as molten iron will not weld to it, as in the case of cast or wrought iron, and does not burn or drill it to anything like the same extent. They are, in consequence, found to endure for a much longer time, and hence American furnaces are not so frequently standing while tuyeres are being changed as is the case with us. The additional cost of tuyeres is thus more than compensated for. An American author, writing of an iron smelting, remarks that "time is iron." It needs one to be accustomed to rapid blast furnace working to fully appreciate his application of the old saying, with which you are doubtless acquainted.

Thirdly, the American manager fixes his tuyere at a higher distance from the bottom of the hearth than we as a rule do. In England 3 to 4 feet above the tapping hole is the height usually adopted, while 5 feet 6 inches is the American rule. The result is that his tuyeres are kept clean and free from slag to a greater degree than ours are, which enables him to blow into clean material, offering less resistance to the blast than if contaminated with slag.

Fourthly, most American furnaces are blown with blast heated in fire-brick stoves of the Cowper or Whitwell type. While they have not so much advantage over Cleveland in this respect, they certainly have the lead of South Staffordshire. It is a fact scarcely worth repeating here that blast of from 1,400° to 1,500° Fahr. will give a considerable saving of fuel, when compared with that heated by pipe stoves even of the best kind.

The average weekly production of a Cleveland furnace is probably not more than about 500 to 550 tons at the present time. It is true that individual furnaces at times reach 700 tons on Cleveland pig, but they are exceptional. Cumberland furnaces on hematite pig reach 800 to 900 tons occasionally, while in our own district 300 tons is rarely exceeded. Fig. 9 of the sections represents the Edgar Thomson "A" furnace, which was blown in on January 4, 1880. Four hundred and forty-two tons were made the first week, 506 tons the second, 528 tons the third. In March, 1880, nearly 700 tons per week were being made with 20·65 cwt. coke of 85 per cent. carbon per ton of pig, and, if my memory serves me correctly, I think this furnace shortly afterward was run at about 1,100 tons weekly. This was one of the first swift American furnaces, and in April, 1880, Taws & Hartman call attention to the following points in connection with it: (1) Its large hearth, 8 feet 9 inches, now cut to 10 feet 9 inches at the tuyeres. (2) Hot blast and high pressure. (3) Tuyeres evenly spaced all around. There is no fore-hearth; use Lurmann cinder notch. Small tuyeres, and blast well projected into the furnace. (4) High furnace, five times bosh; large top, 10 feet 6 inches at stock line. (5) High tuyeres, 5 feet 6 inches above hearth. (6) Able management by founder.

Mr. E. Windsor Richards described the furnaces at the Cleveland Institution of Engineers in 1882, shortly after they had commenced work. He stated that they were then making 1,470 tons of pig per week, with a coke consumption of 22 cwt. They are 80 feet high, 20 feet diameter of bosh, 11 feet 6 inches diameter of hearth, and have 8 tuyeres, each 6 inches diameter, blast pressure 10 lb. per square inch. Temperature of blast about 1,400° Fahr., heated by three Cowper stoves to each furnace. The ores contain 53 to 55 per cent. metallic iron. A plant of two furnaces of this description would cost in England, Mr. Richard says, nearly £100,000, and double that amount in America. There are two pipes conveying the air from the engine to the furnaces which may be worked together or separately. If one furnace is found to be driving slowly the connections are separated, and the blast turned on to the slow driving furnace, and the blast forced through it, thus compelling it to move faster. These furnaces run about two years, or make from 150,000 tons to 200,000 tons of pig before they require relining. Since the date named above, as much as over 1,800 tons per week have been made with a coke consumption of about 20 cwt.

One of the South Chicago furnaces of the North Chicago Rolling Mill Company was described in a paper by Mr. E. C. Potter, general superintendent, at the spring meeting of the Iron and Steel Institute, 1887. It is 75 feet high, 20 feet diameter of bosh, and 11 feet diameter of hearth. On March 30, 1885, this furnace was blown in. During the following nine months 52,927 tons of pig iron were made, which averaged 1,357 tons per week. The coke consumption over that period averaged 20·34 cwt. per ton of pig. In November of that year 6,242 tons were made, which is equal to 1,456 tons per week. Coke averaged 18·77 cwt. During the last six months of that year, the coke consumption averaged 19·12 cwt. per ton of pig. The only fault I find with this furnace is that the bosh is too high, and the height a little too low. In a 75 foot furnace the bosh stands 35 feet above the hearth, whereas with the Edgar Thomson "D" and "E" furnaces, which are 80 feet high, the boshes stand 33 feet above the hearth. Had the South Chicago lines more nearly approached those of the Edgar Thomson, other things being equal, there is little room for doubt that this furnace would have made 1,800 tons instead of 1,400 tons per week, with as low a fuel consumption. Each South Chicago furnace is blown with blast at about 1,400° Fahr., heated in three Whitwell stoves 60 feet high by 21 feet diameter. Tuyere line 5 feet 6 inches above floor; blast pressure, I believe, is from 7 to 8 lb.; the number of tuyeres not mentioned.

The Franklin furnace, New York, represents a different class of work to the Edgar Thomson and South Chicago. The fuel employed consists of about two-thirds coke and one-third anthracite coal. It is a well known fact that furnaces using anthracite do not work so quickly nor so economically in point of fuel consumption as coke-burning furnaces. I believe the average make of an ordinary New York furnace is about 350 tons, but of that I am not quite sure. The Franklin furnace made in one week, selected by Mr. Hartman, 614 tons, with 25·38 cwt. fuel of the mixture named per ton of iron. The ore contained 44 per cent. metallic iron. The air is heated in fire-brick stoves, and averaged 1,100° F. Since making the 614 tons here noted, the furnace has made 692 tons on the same mixture of ore. Twelve years previously, the same furnace, 10 feet lower in height, made 156 tons weekly from the same ore.

In conclusion, although only the Edgar Thomson and Chicago coke furnaces have been taken as types of American rapid work, it must not be supposed that these works alone constitute the show. Other furnaces, such as the Lucy and Isabella, have run up to 1,800 to 2,000 tons per week. In anticipation of any remarks that may be made about the American tendency to "brag," it should be said that the figures given us by our American friends have been accepted and confirmed by many leading members of the Iron and Steel Institute.

W. H. BURFEIND suggests the use of bromine for the extraction of gold from auriferous materials, in the laboratory, and perhaps in the works also. A weighed quantity of the ore is roasted, agitated in a bottle with bromine water, and more bromine added, if necessary, until there is still an excess of bromine after an hour or so of contact. The precipitate is well washed with water, and the filtrate treated in the same manner as if chlorine had been used. Bromine has the advantage, in the way of convenience, of requiring no generating apparatus or operations, as is the case with chlorine.

[Continued from SUPPLEMENT, No. 684, page 10933.]

YEAST: ITS MORPHOLOGY AND CULTURE.*

By A. GORDON SALAMON, A.R.S.M., F.I.C., F.C.S.

LECTURE IV.

THE investigations which we have so far made concerning the various forms yeast, its ultimate composition, the constituents of the living cell, the kind of food which it requires, and the mode of combination in which that food must be presented for assimilation in order that vital vigor may be sustained, will have prepared us for an appreciation of the properties of malt as a yeast food, and will further permit of our ascertaining to what extent practical operations should in this respect fulfill the demands of scientific teaching.

It has been shown that the most favorable form of yeast food comprises three essential groups—carbohydrates, proteids, and mineral matter. Of the carbohydrates we have seen that the various sugars are the most easily assimilated, provided they are in a state of solution. The selective action exhibited by yeast in the matter of nutriment extends, however, not only to specific groups of the carbohydrates, but also to the sugars themselves. Of the true saccharomycetes it may be said that maltose and glucose constitute respectively the most suitable carbohydrate combinations, inasmuch as they comply with the most stringent requirements of a saprophytic food. I am not aware of any experiments which have shown that the dextrins are capable of direct assimilation, nor do I believe them to be so, but they are gradually resolvable into maltose by hydrolysis, and hence their utility in providing a continuous supply of maltose during the later periods of fermentation at once becomes apparent.

It is, however, most important to bear in mind that all fungi that are capable of inciting alcoholic fermentation do not comport themselves in the same manner toward sugar solutions. For instance, all the true saccharomyces hitherto described can ferment maltose, but *S. exiguus* and *S. apiculatus* are unable to do so. Herzfeld, and Brown and Morris, have discovered and isolated a compound termed malto-dextrin, an ultimate product of the hydrolysis of the higher dextrins. This compound cannot, according to the statement of the latter investigators, be split up into maltose and dextrin by the action of *S. cerevisiæ*. They do find, however, that it can be thus resolved by the action of *S. pastorianus* and *S. ellipsoideus*, though we have yet to learn which particular varieties of these species are capable of effecting this further degradation. Again, we have seen that a true saccharomyces secretes within its cell a so-called soluble ferment, invertin, which is able, in case of need, to complete the preparation of the saprophytic food by rendering it assimilable. This is the case of cane sugar, which can be thereby modified by the alterative action of the invertin, and converted into the assimilable glucoses, lævulose and dextrose.

But the possession of secreted invertin is not common to all alcohol-producing fungi, and, consequently, they are unable to effect the transformation of cane sugar into glucose. This is true of *S. apiculatus*, and of four out of the five varieties into which Hansen resolved the species of *torula* as described by Pasteur. On the other hand, *Monilia candida*, although not secreting invertin, is enabled to effect the direct alcoholic fermentation of cane sugar. It may be that this is due to the possession of some soluble ferment other than invertin; but upon this point there is, at present, no forthcoming reliable information.

This dissimilarity in the behavior of the various alcohol-producing fungi toward the carbohydrates is one among the many powerful reasons which lend weight to the argument that in order to insure uniformity of product upon the commercial scale, the culture of yeast requires to be just as pure as for the purpose of laboratory experiments.

With respect to the choice of nitrogenous food, yeast is equally selective in character. We have seen that such food preferably belongs to the class of bodies known as proteids, and that if it be assimilated within the cell, as would seem highly probable, it must, so far as at present known, belong to the sub-group of peptones; because, as I have already stated, they are the only class among the proteids which are diffusible, a property which has been shown to be indispensable to fungal nutriment. But proteids are convertible into peptones by means of certain soluble ferments, and in this way proteid food other than peptones is rendered available in assimilation. In ordinary plant life it has been proved that protein may be manufactured within the cell system, provided that the necessary elements are to hand: and it is certain that it may also be produced from some members of a group of bodies known as amides, a familiar and important example of which is furnished by the substance asparagin. Combination with the necessary proportion of sulphur will convert asparagin into proteid matter, and in this way it and possibly other amides may be of great service in providing nitrogenous fungal food. It would appear highly probable that just as some fungi will ferment maltose, and others will not, so do they exercise a choice in the selection of peptones, both with respect to their ultimate composition and mode of aggregation of their constituent atoms. Of this there is, at present, no direct proof. We do know, however, by practical experience, that in the preparation of beer the presence of certain types of nitrogenous combination is essential, and that of others unfavorable; and there is, moreover, ground for believing that the regulation of the quantity and type of soluble nitrogenous matter in wort will prove to be more in the hands of the maltster than of the brewer, though, perhaps, under the control of both.

It may facilitate the practical application of considerations arising out of these remarks to indicate the necessity which exists for paying more attention than has hitherto been the case to the chemical composition of hops employed in the production of beer wort, and to emphasize the effect which wort, prepared with hops devoid of certain essential characteristics, may subsequently exert upon the progress of fermentation. In a manner admittedly empirical, the brewer at present knows that some nitrogenous combinations exercise a salutary influence, whereas others are capable of exerting an injurious effect upon fermentations. It

* Lectures before the Society of Arts, London, 1888. From the *Journal* of the Society.

is further known that certain of these combinations are precipitated by the tannin of the hops during the process of boiling in the copper, while others remain in solution notwithstanding its presence.

The brewer's experience teaches him that it is desirable that the wort should "break" well in the copper; and that the precipitation by the tannin should be as complete as possible. Yet he seldom, if ever, inquires whether the variation in the quality or quantity of the hops he employs effects any alteration in this particular direction. Chemical examination, however, reveals the fact that the amount of tannic acid contained in hops is subject to fluctuation within very wide limits, and cases are within my experience in which deficiencies in this respect should certainly have been made good. Moreover, the nitrogenous matters themselves contained in the hop should not escape attention, especially when regarded in connection with the ratio which they bear to the tannic acid present. This subject, suggested to me by Mr. Frank Wilson, is being investigated by my talented pupil, Mr. H. B. Woldridge, and I am confident that the publication of his experiences, when complete, will clear up many points at present obscure.

With respect to mineral ingredients: phosphorus, sulphur, potassium, together with calcium or magnesium, have been shown to be essentials; others, such as chloride of sodium, may be, and probably are, of vast importance in controlling the production of the proper type of yeast food; but reliable experiments in this direction have yet to be made.

Now, when we apply the facts at our disposal concerning yeast nutrition to the consideration of the composition of a normal wort prepared from well made malt, we find that all the most favorable conditions are obtained. Carbohydrates are in their most desirable form, viz., as maltose and dextrin. Nitrogenous bodies are represented by proteids and amides, and there is an abundant though not an excessive supply of mineral elements.

By suitable regulations of the conditions of mashing the grist, or crushed malt, and that more especially with respect to temperature, it is possible, as brewers well know, to modify the ratio of maltose to dextrin within somewhat wide limits. This variation is of great importance in practice, because undoubtedly, with an increasing amount of dextrin in the wort, there is a greater palatefulness in the resulting beer. The fermentation is, however necessarily more prolonged, because dextrin, not being directly fermentable, has first to be converted by hydrolysis into maltose. Hence with a beer containing a high percentage of dextrin there is a gradual accumulation of "condition" as the beer matures. It is therefore both desirable and usual to increase the normal ratio of dextrin to maltose in the case of stock ale. In that, however, of an ale intended to be rapidly brewed and consumed, it is obviously desirable to produce the maximum available ratio of maltose to dextrin. Up to a temperature of about 140° F. the proportion is constant, viz., about 81 parts by weight of maltose to 19 parts by weight of dextrin. Beyond this, within a range of 40° F., there is an increase in the ratio of dextrin to maltose with each accumulating degree of temperature, until at 180° F. there is an end to the process of hydrolysis; in other words, there is no further conversion of starch into maltose and dextrin under the normal conditions of wort production by infusion.

It is true that these facts with respect to the influence of temperature upon the ratio of maltose to dextrin, for which we are indebted to the researches of O'Sullivan, and of Brown and Heron, have been of great practical value to those who have known how to apply them intelligently; but, on the other hand, they have been grossly abused by brewers possessed of that small amount of knowledge of the chemistry of fermentation which constitutes it dangerous. Should a brewer, not over ripe in experience, find that his beers are becoming "fretted," or that he has any trouble with his fermentations, the first step he takes is to drop or raise his mashing heats a degree or two, patiently retiring to his brewing room to await the result of this momentous operation. If he were asked why he had altered his temperatures, in nine cases out of ten he could not give a satisfactory, or, indeed, an intelligible, answer. I may go further, and say that even if he had by chance done what was right, there are but few who could really explain the *rationale* of the procedure. Without doubt, a considerable amount is known about the chemical conditions of mashing, and the value of a correct appreciation and application of that knowledge cannot perhaps be overestimated. But mashing is but one stage in brewing, and it should not be forgotten that it is but preliminary to the growth of yeast, which is, after all, the chief care of the brewer. It will be found, as a rule, that most English brewers mash upon sound lines, and trouble, when existing, is generally traceable to the yeast or to the other materials employed. Change of yeast, thorough cleansing of apparatus, attention to attemperation—for instance, turning on the "liquor" sufficiently early—and to the degree of attenuation suitable to the wort employed and the beer it is desired to produce, and, above all, insisting upon being allowed to brew with well made malt and good hops, will, I venture to think, do more real good in overcoming trouble in the brewhouse than any amount of experimental variation in the mashing or sparging heats. My experience prompts me to assert that, in all cases in which bad beer is being produced where it was formerly good, the first step is to obtain pure yeast, the next, well made malt and good hops, and that it is scarcely ever advisable, in such a case, materially to alter the plan of brewing, which has perhaps been handed down in the particular establishment for generations past, and which in competent hands and with suitable material has yielded results eminently satisfactory.

In connection with malt, it is well to bear in mind some valuable experiments conducted by Graham regarding the influence of kiln temperature upon the wort ratio of maltose to dextrin. They show conclusively that this ratio is quite as much, if not more, modified by variation in kiln drying as by alteration in the mashing heats. Hence, if a brewer accustomed to use a very high dried malt has planned his brewings to suit it, and was then compelled, owing to injudicious purchase, to brew with a malt finished off on the kiln at a temperature of some twenty or thirty degrees lower, it would naturally follow that he would not get the same fermentations or attenuations as those to which he had been accustomed. It is clear that in such circumstances, which are of daily occurrence, it does but little practical good to modify the mashing heats by a few degrees one way or the other. Moreover, it is a very great inconvenience for a brewer to be constantly altering the conditions of his working. Assuming that this is necessitated by the variable nature of his malt and his yeast, it is obviously of importance to define a scheme which will enable him to maintain the uniformity of both.

In formulating this, let us first of all direct our attention to the malt. Now, granting that the object of the brewer is to secure uniformity of result, that is that one gyle of beer shall consistently turn out as well as another, that he uses the same heats, the same plant, and the same general conditions of working from day to day, it necessarily follows that in order to obtain the desired uniformity of product he must work with a raw material that is within narrow limits, constant in its composition and its properties. My own experience justifies the assertion that these conditions are seldom fulfilled by the general run of malt for sale as made in this country.

In order to test the accuracy of this statement, it is necessary to determine a satisfactory series of standards by which the malt shall be analyzed and judged. The object of the maltster in preparing barley for the mash tun is, in the main, twofold. He seeks, by suitable germination of the barley, to develop the formation within the grain of a soluble ferment termed diastase; and, further, so to modify the physical properties of the starch cells of the barley, that after the latter are malted, crushed, and suitably infused with water, they shall be readily gelatinized and broken, so that their granulose contents may escape and be rapidly acted upon by the diastase which has been formed. The action of diastase in effecting starch transformation is similar to that of all soluble plant ferments. It is alterative, or gradual, not radical or destructive, as with organized ferments. Within certain limits of temperature, and in the presence of water, which is absolutely essential to the action, the diastase is capable of converting dissolved starch into dextrin and maltose, the proportional composition of which may be varied, as we have seen, by the heat at which the malt has been dried and by the temperature of the mashing liquor.

Now, if the work of the maltster has been properly performed, diastase should be present in active quantity, and the starch cells should be so modified by the process to which the grain has been subjected that, when the malt is infused, the whole of the available starch should be converted within a short and fairly constant space of time. It will be apparent that if complete saccharification of starch takes place with one malt after the lapse of thirteen minutes, and with another, treated under identical conditions, only at the end of an hour and a half, it is hopeless to expect uniformity of product or regularity of working. Yet these are figures which have actually come under my experience, in a case in which an explanation was required of irregularity of fermentation and instability of resulting beer.

In ordinary circumstances far more diastase is formed in a malt than is theoretically required to effect the conversion of its contained starch; but when, as so often happens, the excess is utilized in the conversion of added starch products, such as rice or maize, it follows that it should be present in quantity sufficient to effect the purpose for which it is then employed, and it needs but slight reflection to admit the importance of maintaining the constancy of its amount. We know little enough about the action and composition of diastase, more especially in its relation to the other nitrogenous bodies found in wort; but of this we may be sure, that if in a malt yielding excellent results it exerts a converting power represented by 100, and in another malt, brewed with the same plant and under identical conditions, it only possesses a converting power represented by eight, it is not fairly to be expected that the beers yielded by the two malts will be uniform in quality, or that, under such conditions, the yeast will maintain its vigor and regularity of growth. Yet these, again, are figures which have come within my own practical experience.

It is remarkable how much information an experienced brewer or maltster can gain by critically examining a sample of malt and then biting a few of the corns, but he cannot form much of an opinion as to its conversion into brewing sugars, either in respect of time or of its diastasic power; neither can he predict, with much prospect of success, whether the malt will produce a stable or a fretting beer. Yet these are factors of too great importance to be ignored by those who wish to brew a wort of constant composition, and a beer of uniform flavor and keeping properties.

If we turn for assistance to the chemical analysis of malt, the information afforded is lamentably inadequate. Indeed, as generally carried out in this country, the analytical figures have scarcely the practical value of the paper upon which they are written. I am conscious that in making this statement I am charging myself with inconsistency, because I have made many analyses such as those I now condemn, but I may perhaps be allowed to state in extenuation that, since I formed the views I now hold, I have always added to such analyses determinations to which I shall presently allude, and which in a great measure, if not fully, compensate for the valueless nature of the other figures.

The determinations usually made are as follows: Maltose, dextrin, soluble nitrogen calculated as albumenoids, acidity in terms of lactic acid, ash, total dry extract, moisture, dry grains, and brewer's extract per quarter. Let us now subject these estimations to a critical examination.

A brewer who looks at a malt, and then bites it, should be able to say without hesitation whether it is high or low kiln dried. With a knowledge of, and due reference to, Graham's experiments, he will then be able to tell whether the ratio of maltose to dextrin is above or below the normal amount. An experienced man will, moreover, make the estimation far faster than a chemist could possibly hope to do, and unless the latter analysis be most exhaustive and be performed with the aid of a polariscope, which is absolutely essential if accuracy be required, the former will be for practical purposes as reliable as the chemist's figures. We have not yet a sufficiently intimate acquaintance with the compounds intermediate between maltose and dextrin formed in mashing to enable a brewer to derive any reliable information from an inspection of figures in which the maltose or dextrin vary with respect to one another only to the extent of one or two per cent., and this being the case, I am unable to perceive the value of such repeated estimations; always premising that the brewer is sufficiently intimate with the investigations of Graham, O'Sullivan, and Brown and Heron, to which I have referred. If on the other hand he is not acquainted with them, he will be totally unable to appreciate the meaning of the maltose and dextrin values actually presented to him as the result of malt analysis.

The determination of total soluble nitrogen as albumenoids is untrue upon the face of it, because it expresses the nitrogen due to the important class of bodies known as amides in terms of albumenoids or proteids, when as a matter of fact they do not belong to the group at all. Nevertheless, they exist in malt-wort to a very considerable extent, and do indeed exert a far more favorable influence upon the nutrition of yeast than several groups of proteids, with which they are erroneously included. In ordinary circumstances a malt might be condemned as unfit for the production of stable beer because it gave a high record of nitrogen when calculated into proteids; whereas it might well be that the proteids were low and the amides were high in amount. In such a case the conclusion would not only be worthless, but actually misleading. If the nitrogen estimations be made, after the system of Ullick, in terms of amide, albumenoids, peptones, and nitrogenous combinations of an unknown character, then the figures possess a real value which would be increased if these were collated with the practical results obtained by using the malt which had yielded them. But the process is very tedious and complicated, and it is not a matter of surprise that it is not more generally used.

A maltster has only to bite a sample of malt, and he will at once know whether or no it is "slack." That is, he will be able to tell without the chemist's assistance if it contains an undue amount of moisture. In such a case he would expect to find a high proportion of acidity, because it is well known that the presence of moisture is favorable to its formation. There is, however, very little ground for believing that the total acidity in malt is due exclusively to lactic acid, because of the difficulty of estimating the other acids to which it should possibly be referred. The estimation has, therefore, but little to recommend it.

The ash in malt scarcely ever varies more than a few tenths one way or the other from 2 per cent.; a knowledge of this fact obviates the necessity for continuous determination.

The extract of malt, as determined in the laboratory, is nearly always erroneous, because of the difficulty of obtaining an accurate record, on the small scale, of the number of pounds of malt that will, in practice, be found to constitute a bushel. This will, as brewers and maltsters well know, vary with the method of loading, and I have found that these results, when obtained in actual practice, scarcely ever accord with those yielded at the hands of the most competent analysts in the laboratory.

The net result, then, of all these determinations is that they convey very little, if any, new or useful information to the brewer. There are, however, many points in connection with malt and its making upon which information should be forthcoming, because they are of vital importance in connection with malt considered as a yeast food. The brewer is seldom able to tell by his own or by a chemical examination of malt whether the barley has been subjected to insufficient or excessive steep; whether the sprinkling on the floors has been properly managed; whether the water has been added in too great quantities at a time, or at the wrong period of growth; whether the malt has been loaded too early upon the kiln, or whether the heat has been applied too strongly at the early stages of kiln drying and before the moisture has been expelled. In the latter case the diastasic power would be greatly reduced, in addition to the formation of a vitreous film upon the surface directly next to the husk, which would protect the interior from the due action of the heat, and would produce an imperfect malt, generally unsound, and incapable of saccharifying completely within the limits of time normal to a well-made malt.

These products of carelessness can be controlled, at least provisionally, as I have found after many practical experiments, by the three following determinations:

1. The stability of the wort obtained from infusion of the malt when "forced" at a high temperature in sterilized flasks.
2. The time required for complete saccharification.
3. The diastasic power as compared with that of a standard malt calculated as equal to 100.

There is room for considerable variation in the manner in which these determinations may be made. I find, however, that the results are of great value when conducted as follows:

Stability.—Ten grammes of the malt, which should have been sampled in a carefully cleaned tin, are mashed with 100 c. c. of recently boiled water at a temperature of 158° F. for two hours. The wort is then filtered into a small sterilized flask. The latter is previously heated for several hours in a hot-air oven at about 300° F., and the filter paper and funnel are likewise sterilized at the same temperature. The neck of the flask is plugged while still in the hot oven with sterilized cotton wool, and the funnel inserted through the wool. The whole apparatus is then covered with a bell jar, so that the possibility of the advent of fortuitous germs is well guarded against. When the filtration is complete, the funnel is carefully withdrawn without disturbing the cotton wool, and the flask containing the wort is removed to an incubator at a constant temperature of about 85° F. The contents of the flask are placed under observation, and their condition noted every twenty-four hours. If at the end of forty-eight hours the worts are bright, and exhibit no "mothering," I consider that they have satisfactorily withstood this important test. A well-made malt will always do this, a badly-made malt never, unless it has been so imperfectly malted as to be nearer raw grain than malt, in which case it is obvious that it will not offer so favorable a nidus for fungal nutriment as would a malt, but in this event its defects would be detected by the experiments which follow. It is unnecessary to dwell further upon the importance of mashing with a malt free from foreign and objection-

able organisms, and it will be found that the method of examination as above explained is an easy method of attaining this desirable end.

Time of Saccharification.—Ten grammes of coarsely ground malt are introduced into a small beaker, and 100 c.c. of water at 158° F. are added and well stirred in with the malt. The beaker is immediately placed in a water bath, also maintained at a temperature of 158° F. In these conditions the mash, which is frequently stirred, is periodically tested with iodine solution, the time from the commencement of the mashing until no starch reaction is obtained being carefully noted.

Diastasic Power.—Twenty-five grammes of coarsely ground malt are digested for about three hours with cold water; the amount of water is made up to exactly a liter. It is occasionally shaken. At the end of the three hours the solution is filtered off bright. Three grammes of pure starch, preferably in the form known as "soluble" starch, are next mixed with 500 c. c. of water, and heated to 180° F., with constant stirring. This starch solution is then made up to one liter. 100 c. c. of the starch solution are placed in a flask and heated to 140° F., and 25 c. c. of the bright aqueous malt extract are then added, the whole being kept at the temperature of 140° F. for 20 minutes. The solution is then raised to the boil for a moment only, so as to stop further conversion. 50 c. c. of the solution are now taken, and the copper oxide reducing power gravimetrically determined. This is compared with that of a fair standard malt similarly treated, the latter being taken as equal to 100.

It will be seen that the above estimations are simple, and are capable of being rapidly performed. I do not for one moment claim originality for them, but I do not hesitate to advocate their adoption. Each brewer should, in my opinion, fix his own standard, and demand that his malt should be delivered up to it. I have, for instance, found it advisable to fix the following limits for stock or pale ale malt. It should take between 20 and 30 minutes to completely saccharify. It should have a diastasic power not lower than 90. The "forced" wort should remain bright at the end of 48 hours, and should not then have developed any "mothering."

The judgment of the malt should be formed, in conjunction with the ordinary methods of testing, upon these three determinations taken together. The maltster may grumble at first at having to fulfill such requirements, but when he finds that it is insisted upon he will, by due attention to the various stages of malting, be enabled to meet them, and deliver malt constant and uniform in properties. This done, I feel assured that one of the chief causes of irregularity of fermentation and bad beer production will have disappeared; and I have therefore no hesitation in recommending this method as a valuable auxiliary to the general examination of malt as now performed by the brewer.

It is desirable, before proceeding to discuss the method of producing pure yeast in the brewery, that we should dwell briefly, at any rate, upon the means whereby two essentials of a good brewery wort may be attained, the one efficient aeration, the other sufficiently prolonged cooling without exposure to conditions which invite contamination by organisms which may be and generally are present in the air of cooler rooms.

Granting the necessity of aeration, it is obvious that it can only be secured under the conditions at present obtaining in this country by protracted exposure, and by the use of very shallow coolers. If the depth of beer were great, the aeration would only take place, with any approach to thoroughness, upon the surface of the wort, while cooling in such circumstances would be prolonged until it were impracticable. It is this very exposure to the influences of non-sterile atmosphere which constitutes a source of danger in the production of beer. Especially is this the case in the neighborhood of large towns, where the air is admittedly impure. Exposure of wort in this way at temperatures best adapted to germ multiplication before the yeast has been introduced constitutes without doubt a blot upon our system of beer preparation.

How best to obviate the defect is a question which requires most careful attention. Pasteur went so far as to devise an apparatus destined to accomplish the object, and it is within the knowledge of many of you that it has been erected and worked in English breweries. It will be freely admitted that it was theoretically sound, and should, *prima facie*, have yielded good results in practice. Indeed, it was, doubtless, such considerations that induced the proprietors of some of our breweries to sanction its adoption. It was, however, unsuccessful in practice. To discuss the reasons of its failure would detain us too long. It may suffice, therefore, to say that the views of the illustrious inventor did not receive complete application in the apparatus in question, and the flavor of the beer which passed through it was not such as to commend it to our brewers.

This failure should not, in my opinion, prejudice us against another apparatus constructed with a similar object in view, by Velten, of Marseilles. I am not aware of its having been erected in England, but I have seen it working on the large scale in some of the best breweries on the Continent, and have heard none but satisfactory accounts concerning it. Its action is rendered easily intelligible by reference to the illustration.

It will be seen to consist essentially of an air-tight vessel, preferably of copper, in the center of which is fitted a powerful refrigerating apparatus, through the tubes of which water of any desired temperature can be passed. A shaft piercing the cooler vertically terminates in a screw which can be actuated by machinery from without.

The vessel is well sterilized by steam, after being cleaned and closed down, prior to the introduction of the wort. The latter is admitted by the pipe, M, which is suitably controlled by a cock. Its exit when cooled takes place through the pipe, N, whence it passes direct to the fermenting tuns. When the cooler is filled with wort, the screw is caused to rotate, the sterilized air admitted by the pipe, H, and the cold water passed through the coil. This is continued until the desired pitching temperature is attained, when the screw is stopped, together with the flow of cold water, and the wort allowed to rest in order to deposit suspended and precipitated solid matter. I should not be justified in the assertion that this apparatus would be found to answer in English breweries, because I have not seen it applied to the high fermentation system; but I can see no reason why it should not be successful, and in this case the saving in respect of space would obviously

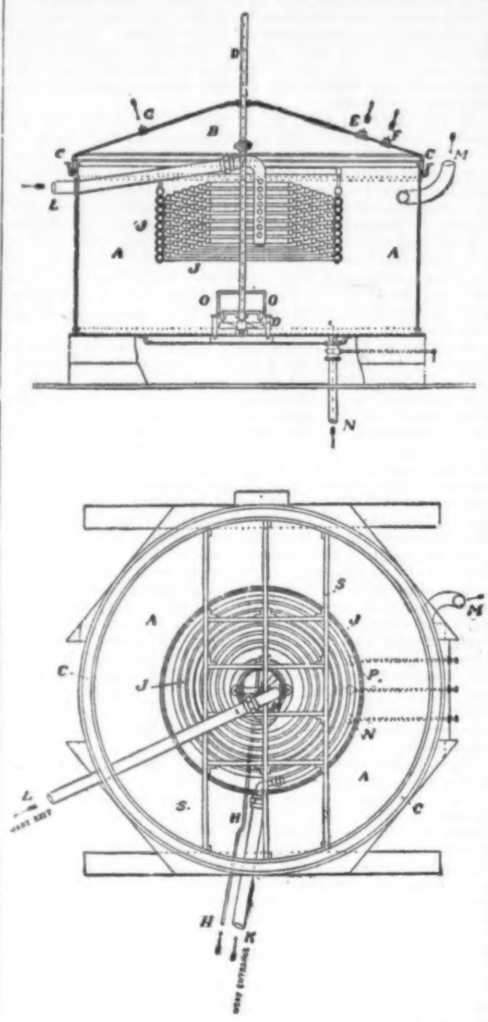


Fig. 30.—VELTEN'S COOLER. (Holm.)

A, the wort vessel; B, removable cover; C, water packing; D, axis terminating in screw, usual rotation 130 revolutions per minute; E, F, steam exits; G, opening for introduction of sterilized air after the cooling of the wort; H, pipe fitted under the screw for the introduction of sterilized air during the cooling of the wort; J, spiral refrigerating system; K, I, water entrance and exit of same; M, wort entrance; N, wort exit; O, manhole.

be very great. The wort remains in this vessel in all about three hours.

(*To be continued.*)

THE COLORADO OIL FIELDS.

By Prof. J. S. Newberry.

In a paper read before the New York Academy of Sciences, November 26, 1888, President J. S. Newberry gave the following as the results of his recent investigations in Colorado:

The only wells thus far worked are at Florence, near Canon City, in the valley of the Arkansas. Indications of gas and oil are, however, found over a very wide territory, and the industry is no doubt still in its infancy, although surface indications cannot always be relied on as indicative of workable wells. Thus, in California, such indications are numerous and copious, yet the stratigraphical conditions are such that few paying wells can be sunk there, the oil having been mostly lost.

In Colorado the oil-bearing horizon is the Colorado shales, the middle member of the Cretaceous group. The succession of strata is best shown in the northwest corner of the State, near Glenwood Springs. There the strata have been turned up at a high angle and show the following order within a distance of some four or five miles, Grand River running through the middle, viz.: 1, Granite; 2, Potsdam sandstone; 3, Paleozoic limestone; 4, Trias; 5, Jura; 6, Dakota; 7, Colorado shales; 8, Laramie group; the last three Cretaceous. The shales at this point are black and over 2,000 feet thick. On the plains, limestone takes their place.

Oil was found near Canon City twenty years ago, but it was not till three or four years ago that the first paying well was sunk. At the time of the speaker's visit twenty-five wells had been sunk. Mr. Wallace, representing the company, reports the number now increased to forty. None of them are gushers, but they flow generally in a steady stream, yielding from 20 to 100 barrels a day, the average of the wells now being pumped being between 50 and 60 barrels. The daily yield is now about 1,000 barrels.

About all the oil land in that portion of Colorado is owned by one company, some 50,000 or 60,000 acres, but borings have thus far been confined to a very limited area, not exceeding 500 acres. The advantage of the present field of operations is its accessibility to market, but the prospect for oil appears to Dr. Newberry good in other portions of the State which are underlain by the Colorado shales.

The Colorado oil fields add a new horizon to those from which oil has heretofore been obtained. The supply at Findlay, Ohio, Burkesville, Ky., and Collingwood, Canada, comes from the Lower Silurian, while in the great fields of Western Pennsylvania and Western New York the oil is derived from the Devonian black shales which underlie that region and have a thickness of 500 feet. The oil of Mecca, Ohio, is taken from the Berea grit, and originates in the Cleveland black shale which underlies it.

The Colorado oil has a pleasant, ethereal odor, in this resembling the oil obtained from tertiary rocks near Mantua, Italy, which was used for street lighting at a remote date, being, indeed, the earliest use of petroleum of which there is any historical record. It has, when crude, a gravity of 31 degrees B., and yields, on refining, 40 per cent. of pure white oil, the clearest and finest known. It is very easily refined and deodorized. The residuum is rich in paraffine, making the most perfect lubricant Dr. Newberry has any knowledge of. It would be worth in Eastern markets 50 cents to $1 a gallon, but the company use it for fuel, and though this is bad economy, it makes an ideal fuel.

The origin of petroleum has been a vexed question, chemists holding one theory and geologists another. The eminent chemist Mendeljeff supposes it to be formed from inorganic elements by natural synthesis, but Mendeljeff had no personal acquaintance with our great American oil fields. His theory is a theory only. In volcanic and metamorphic regions the inorganic elements exist abundantly and in juxtaposition, but oil is never found there, thus refuting the theory. [Dr. Newberry omitted to mention the fact that Mendeljeff had actually produced petroleum by synthesis in his laboratory.—*Ed. E. and M. J.*]

The geologist finds that oil is always associated with bituminous shales or limestones. Near the outcrop of the carbonaceous shales which underlie Western New York and Pennsylvania oil and gas springs are found associated in position, and evidently so in origin. South of Cleveland, Ohio, oil and gas are found above such shales. They seem to originate in these shales, and are formed from organic matter which goes on decaying. Coal, if left out in the open air, loses all its volatile matter in the same way that these bituminous shales are doing. Thus spontaneous distillation is constantly going on, and petroleum and gas are issuing from decomposing organic matter. Petroleum, decomposing in its turn, throws off volatile gases, leaving tar, asphalt, ozocerite, albertite, grahamite (asphaltic coal), asphaltic anthracite, and, as the last term of the series, graphite, from which all volatile matter has escaped. The transition from oil to asphalt is very well seen in Canada, also in the Pitch Lake of Trinidad, which is fluid in the center and gradually solidifies toward the edges. At Canajoharie, petroleum oozing from the Utica black shales in ancient times has formed seams of anthracite from the thickness of a sheet of paper to those several inches thick. At a mine in Idaho eruptive rocks have formed dikes in carbonaceous (Cambrian) shales, and fissures are filled with anthracite, also a residue from ancient petroleum. In the Laramie rocks of northwestern Colorado are veins of albertite 10 to 20 feet thick, resulting from petroleum which came from the Colorado shales below.

All these examples indicate the methods of operation of natural agencies through secular periods. But similar processes are even now going on. We may see on a small scale the formation of oil in pools where vegetation is decaying. In such places, remote from the great oil fields, a thin film of oil is formed on the surface of the water, and on poking up the mud with a stick, bubbles of marsh gas are set free from the bottom.

All these phenomena point clearly to vegetable tissue as the origin of the various hydrocarbons, whether gaseous, liquid, or solid. Some small proportion may be of animal origin, as adipocere is not infrequently cast up by the sea, but the great deposits must be of vegetable origin. This is confirmed by microscopic examination of bituminous shales, which are found to be full of broken vegetable fibers. A possible source of oil and gas are the minute algæ, such as now in summer abound in some lakes to such an extent as to render the water green and opaque.

These considerations throw light on the question of permanence or failure of supply in gas and oil wells. If the theory of the speaker is correct, 1st, gas and oil springs and wells must be confined to strata overlying beds of organic matter, such as coal, carbonaceous shales, and bituminous limestone. 2d. Gas and oil will flow from such deposits as long as any organic matter is left. 3d. The daily flow of gas and oil will be small, and great accumulations of either can only take place where fissures or coarse, porous rocks serve as a reservoir, and impervious strata above prevent escape and cause the accumulations of hundreds of years of daily product. Hence gas and oil wells will continue to flow for ages, but when the stock in reservoirs is exhausted or the current production is divided among many wells, the product may be so reduced as to be of little or no value.

The oil wells of Mecca, Ohio, prove the continual formation of petroleum. These wells are bored in the Berea grit, a sandstone which overlies the Cleveland shale, a sheet of carbonaceous matter. When first opened, the Berea grit was found saturated with oil, and several hundred wells were bored in close proximity. These soon drained away the accumulation of oil, and within three months every well was supposed to be exhausted and was abandoned. Now a small but remunerative industry is maintained there by pumping each well a few days in the year. The quantity taken from each, though small, is constant, proving a continued production. As no oil has been obtained there below the Cleveland shale, and gas and oil are seen escaping from that in a multitude of places, we must conclude that they come from the shale.

History confirms this view of permanency in supply. The Chinese have used petroleum for two thousand years, and the Hindoos for many hundreds, and the spontaneous flow upon which they have depended has been constant. On the shores of the Caspian enormous and apparently constant quantities of gas and petroleum have escaped from the ground from time immemorial. The Babylonian asphalt used as a mortar is a petroleum product furnished by the fountains of Hit, which are apparently flowing now as they did thousands of years ago. In all these localities the spontaneous outflow of oil (that is, the daily product of subterranean distillation) has been used, and such sources of supply are permanent, but the steam pump will certainly exhaust local reservoirs of oil, and numerous gas wells will exhaust a territory, however productive in the beginning.

In discussing the paper, Mr. Hidden took issue with the theory of the vegetable origin of petroleum, ad-

ducing the fact that carbon from meteorites has been distilled and oil obtained, and that quartz and granite are found sometimes heavily charged with carbonic acid, either gaseous or sometimes even in a liquid condition.

Professor Newberry replied that the granites which contained carbonic acid and graphite are sedimentary rocks which have been metamorphosed by heat, and their organic hydrocarbons distilled. He had only attempted to explain the origin of the petroleum of this world ; we do not know anything about the conditions of things in worlds other than our own, but analogy justifies the inference that similar causes produce similar effects elsewhere as here.—*Eng. and Min. Jour.*

VIEWS IN GUATEMALA.

The area of Guatemala is some 45,000 square miles, inhabited by a population of about a million and a half. Of these there are 800,000 Indians, 200,000 whites of Spanish origin, and 400,000 whites of mixed blood. The chief product of the country is coffee. Other products are sugar, hides, rubber, cocoa, tobacco, maize, wood, bananas, etc. ; while gold and silver mines of considerable value exist, but as yet are quite undeveloped. There are several small ports on the Pacific coast, where at present the export trade is carried on ; and one, Port Livingstone, on the Atlantic seaboard, with a very fine harbor, which is looked upon as the future principal port of Guatemala, when the railway between it and the capital is completed. There is already a railroad from Guatemala City to the Pacific port of San Jose, and a second from Champerico to Retalhuleo, over which the bulk of the coffee is carried. Throughout Spanish America there is a great scarcity of labor, but in Guatemala this deficiency only exists at present in a few districts, the ordinary wages ranging from 1s. 3d. to 1s. 6d. a day. It is customary for the planters, when they require, say, from fifty to a hundred laborers, to apply to the mayor of the nearest town, who provides them—work being compulsory on those who cannot show that they have any other means of subsistence. When, however, the large tracts available for coffee planting are developed, the difficulty of procuring labor will be increased. At present the cost of cultivating, picking, shelling, and generally preparing a cwt. of coffee for the market is under 16s., while the market price in Guatemala rules about 50s., thus leaving the planter a fair margin of profit. The climate in the coffee-growing region is most healthy and agreeable, ranging from 60° to 80° Fahrenheit in the daytime. The capital, Guatemala City, contains some 70,000 inhabitants, with spacious streets and handsome public buildings. About nine hours' walk is Antigua, or "Old Guatemala," which was forsaken by its inhabitants after the terrible earthquakes of 1773, most of its buildings, as one of our illustrations shows, being in ruins.—*London Graphic.*

THE EGYPTIAN PAPYRUS, TAPA, AND ANCIENT MEXICAN PAPER.

The manufacture of paper is not a new industry. Champollion the Younger found in Egypt contracts upon papyrus that dated back 3,600 years. In the book of Tobit it is seen that the marriage contract between the young Tobit and Sarah, 684 years before our era, was written upon a sheet of paper. If we are to believe certain documents, the Chinese, who, during the first dynasties, engraved their letters upon small tablets of bamboo, discovered paper 213 years before our era. At this epoch the Emperor Tsin-Chi-Hoangti ordered the destruction of all the books written upon bamboo tablets, and his minister, Mung-Thian, invented the paper that was to permit of multiplying the writings that the stern prince wished to have disappear from the celestial empire.

POLYNESIAN AND MEXICAN PAPER BEATERS.

In Mexico and Oceanica also the inhabitants, before the arrival of the Europeans, were manufacturing a sort of paper which was not always designed to be covered with graphic signs.

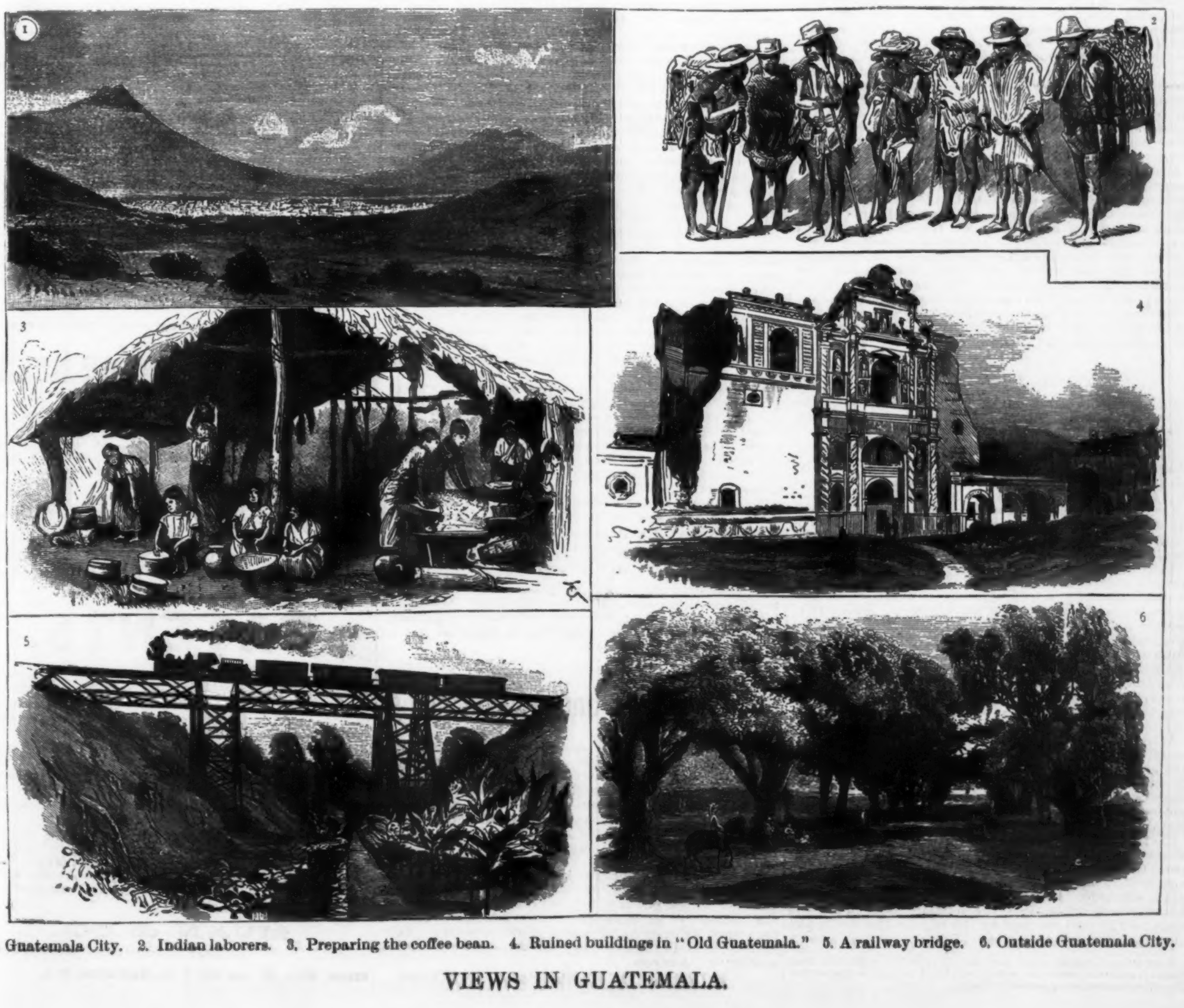
With us, this article is now manufactured from rags or fibrous vegetable substances. When tissues are used, it is necessary, as every one knows, to reduce them to shreds, while at the same time breaking them as little as possible. As long as they preserve something of the arrangement given to them by weaving they cannot be used, the fibrils of the paper having to be interlaced in every direction.

For their papyrus, the ancient Egyptians used a plant which grew spontaneously in the swamps of their country—the paper sedge (*Cyperus papyrus*). They gathered the plant and cut off the root and all that grew above the water, the part of the stalk that had been constantly submerged being alone utilized. After splitting this lengthwise, the manufacturer carefully unrolled the pellicles of which it was composed, cleaned them, and spread them out one against the other upon a plane surface moistened with water. Other pellicles were placed crosswise upon the first. In order to interlace the fibers, the whole was submitted to a beating, and then to a strong pressure, of which the object was to cause the disappearance of inequalities. The sheets were then dried and united end to end in order to obtain rolls of large size. It was also necessary to smooth them, and this operation was performed with pumice stone, agate, or ivory polishers. The paper thus manufactured was more or less fine and white, according as the pellicles had been taken from the periphery or the center of the stalk. In order to preserve it from dampness and insects, it was dipped in oil of cedar. It was to this latter operation that the Egyptians owed the strength of their paper, and this was such that, by means of several superposed sheets, it was possible to make soles of shoes of it.

The use of papyrus spread from Egypt to Greece, to Asia Minor, thence to Rome, and, finally, to several other countries of Europe. It was manufactured in Egypt and sent to other regions. In the year 263 B. C., Ptolemy Philadelphus met in Eumenes I., King of Pergamus, a rival who, like himself, was a protector of letters and sciences. This prince bought yearly from the Egyptians a large quantity of papyrus. In order to prevent his rival from attracting the learned to his court, Ptolemy forbid his own subjects to export papyrus. However, later on the Romans obtained almost all of their papyrus from Egypt, especially from Sais and Alexandria. The use of it was abandoned very late. The popes used it, and it was upon this that the French kings of the first dynasty wrote.

At first, Chinese paper was manufactured, as it often still is, from the bark of trees submitted to a prolonged beating.

It was in the same way that various populations of Oceanica manufactured tapa, a true paper analogous to that of China, although it was designed for the making of clothing. Forster, who was in Tahiti in 1773, with Captain Cook, was one of the first to see the



1. Guatemala City. 2. Indian laborers. 3. Preparing the coffee bean. 4. Ruined buildings in "Old Guatemala." 5. A railway bridge. 6. Outside Guatemala City.

VIEWS IN GUATEMALA.

manner in which the barks were treated. Under a small shed, says he, five or six women seated at the two sides of a long piece of wood were beating the fibrous bark of the mulberry tree in order to manufacture their fabrics. For this they used a square piece of wood having longitudinal and parallel grooves more or less close together, according to the different sides. They stopped a moment to allow us to examine the bark, the mallet, and the beam that served as a table. They showed us also in a cocoanut shell a sort of glutinous water that they used from time to time to glue together the pieces of bark. This glue, which, as we learned, comes from the *Hibiscus esculentus*, is absolutely necessary in the manufacture of these immense pieces of stuff, which, sometimes from six to nine feet wide and one hundred and fifty feet long, are composed of small pieces of bark taken from trees often of very small diameter.

All museums now possess specimens of tapa, either plain or ornamented with designs in color. The museum of the Trocadero has also several of the mallets used for beating the fiber of the paper mulberry (*Broussonetia papyrifera*) in order to interlace its fibers. No. 1 of the accompanying figures represents one of these, the property of Mr. Eugene Boban.

In various provinces of Mexico, cubical instruments of hard stone have been met with having grooves on two of their surfaces exactly like those observed by Forster on the Tahitian tapa beaters. Mr. Boban has several of these. The one that he had the kindness to communicate to us is now the property of Mr. E. Goupil. Like most of the Oceanican beaters, the stone in question is provided with grooves of unequal width upon its two faces. Nothing but a handle is wanting to make them entirely comparable. But such a handle must have existed. The deep notches in the circumference (No. 2) indicate that the instrument was provided with a handle either of leather or flexible wood. If we restore the handle (No. 4), the Mexican beater and that of Oceanica are absolutely analogous. Were they used for the same purpose? It seems to us quite plausible to admit it. In Mexico paper was used not only for manuscripts, but played a great role in civil, military, and religious ceremonies, and a large amount of it was consumed. Cuauhnahuac (now Cuernavaca) had to furnish to the capital an annual tribute of 160,000 packages of it. Nepopohueleo, Tlaxcalla, Tepoxotlan, and other cities paid contributions of the same nature.

Now, this paper was manufactured by processes analogous to those employed in Oceanica for tapa. The learned Francisco Hernandez, sent to Mexico by Philip II., of Spain, saw paper still being manufactured at Tepoxotlan, and he tells us that the Mexicans used the same processes as the Egyptians, and the latter, as we have seen, beat the papyrus. Boturini adds that in Mexico they used the maguey (*Agave Americana*), the leaves of which were macerated and afterward beaten in order to separate the pulp from the filaments. After these have been cleaned, says he, they are spread out in layers that are held together with glue, and, after the desired thickness has been obtained, they are smoothed and are then ready for the market. Boturini, like Hernandez, alludes to the beater used in the manufacture of paper. The Mexicans, however, had a word to designate the operation. They said *amanitequi*, "to beat paper," and *amatequini*, "paper beater." Beating was often the principal operation, when, for example, instead of agave leaves, the bark of *Cordia* was used—a tree of the order Borraginaceæ, which the Mexicans called *amacuahuitl*, meaning "paper tree."

After this, it is not difficult for us to see the beater in the grooved stone so analogous to the tapa beater of the South Sea. This determination seems much more plausible than that given in the catalogue of the National Museum of Mexico, by Mr. Gondra, who would have it either a polisher or a stone for shelling corn. The first hypothesis is little compatible with the small size of the instrument, and does not explain the notches in the circumference. The second is still more hazardous. In order to shell corn, it was not necessary to carefully work a hard stone like the one in question. The first stone that was met with would have rendered the same service.—*La Nature.*

DETECTION OF ANTIMONY.

By ALEXANDER JOHNSTONE, F.G.S., Assistant to the Professor of Geology and Mineralogy in Edinburgh University.

MINERALS which contain antimony, when heated *alone* before the blowpipe on charcoal, or with the *addition* of three or four parts of fusion mixture ($K_2CO_3+Na_2CO_3$), yield dense white fumes of antimonious oxide,* which in great measure escape into the atmosphere, but which also in part become deposited on the charcoal support, forming a well-marked white sublimate, coat, or incrustation of the oxide.

Those results, though certainly in most cases very useful indications, do not furnish to the satisfaction of the mineralogist sound, conclusive evidence of the presence of antimony in the mineral tested, seeing that several other bodies occurring in the mineral world give, when heated before the blowpipe, exactly the same or nearly similar reactions. As a consequence of the hitherto inconclusive blowpipe evidence, mineralogists have usually considered it essential when engaged in correct work to supplement those indications by means of the accurate but tedious method of the ordinary wet way qualitative chemical analysis.

With a view to remove the necessity of consuming so much valuable time over the certain identification of antimony, the author wishes to bring under the notice of mineralogists the following exceedingly simple but thoroughly trustworthy test, which he discovered and successfully applied while working among the various metallic ores of antimony.

To the white coat which will invariably form on the charcoal if the mineral containing antimony be properly treated and heated before the blowpipe, add, by means of a narrow glass tube, a single drop of ammonium sulphide. If the white sublimate is composed of antimonious oxide, then the portion touched by the drop (or the part touched by the *edge* of the drop) will immediately become converted into the well known and highly characteristic *reddish or orange* sulphide of antimony.

As no other white coat producible on charcoal by heating a mineral in the blowpipe flame becomes *reddish* or distinctly *orange* in color when treated as above with ammonium sulphide, the value of this easily applied test must at once be apparent.—*Chem. News.*

* Not altogether *antimonious* oxide (Sb_2O_3) according to Dittmar. That chemical authority asserts that a small portion of the coat is composed of the amorphous antimony tetroxide (Sb_2O_4).

RECOVERY OF TIN FROM SCRAP.

A. S. RAMAGE, Liverpool.

CONSISTS of an improved method of carrying out the process of recovery of tin from scrap by means of hydrochloric acid, zinc, and lime. The scrap is made into bundles and fixed in a cage, and is afterward lowered by means of an overhead crane into a bath of hydrochloric acid. After the tin has been dissolved, the liquor is run into another bath, and a second cage, containing scrap, is lowered into it. This process is continued by placing the scrap with the greatest amount of tin upon it into the most nearly saturated liquor, and by afterward allowing the fresher acid to act upon the plates from which the greater portion of the tin has been removed. The resulting liquor consists of a mixture of the chlorides of tin and iron, and in order to precipitate the metallic tin from it, a certain quantity of zinc is added to it. After having been filtered, the remaining liquid is treated with milk of lime, which deposits the zinc as the hydrate. The zinc hydrate is subsequently heated and transformed into oxide of zinc, and the further addition of milk of lime to the liquor gives rise to ferrous hydrate and chloride of lime. In this manner it is possible to use up all the by-products, and to conduct the operations on an economical basis

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